PUBLIC HEALTH ASSESSMENT

VASQUEZ BOULEVARD AND I-70 SITE

DENVER, COLORADO

CERLIS NUMBER: CO0002259588

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Summary

The Vasquez Boulevard and Interstate 70 (VBI70) site spans approximately 450 acres in northeast Denver. It includes the area that the U.S. Environmental Protection Agency (EPA) has proposed to the National Priorities List of hazardous waste sites as well as an expanded study area. EPA proposed adding VBI70 to the NPL on January 19, 1999, thus requiring ATSDR to conduct a public health assessment by January 19, 2000.

The VBI70 study area is located primarily southeast of the interchange of Interstate 25 and Interstate 70. The study area does not extend further east than Colorado Boulevard, further south than Martin Luther King Boulevard, further north than 52nd Avenue, and further west than the Burlington Northern rail tracks west of Interstate 25. The study area includes all or part of the following five Denver neighborhoods: Clayton, Cole, Elyria, South Globeville, and Swansea. This area includes a mix of residential, commercial, and industrial sections.

One important way that children and adults could get exposed to contaminants at the VBI70 site is from accidental ingestion of contaminated soil and house dust. As people interact with their environment, for instance when children play outside or crawl around on the floor of their house or when adults work in the yard or garden, soil and dust particles cling to their hands. Because people and especially children accidentally put their hands on or in their mouth, they can swallow small amounts of soil and dust particles. This results in exposure when the soil and dust particles are contaminated with arsenic and lead.

Because of their frequent hand-to-mouth activity, preschool children usually have the greatest amount of exposure to contaminants in soil. A special group of pre-school children exists that purposely eat large amounts of soil. This behavior is called soil pica behavior and is most likely to occur in 1- and 2-year old children but can occur with any age, gender, or racial group.

In 1998, EPA collected soil samples from properties in the VBI70 study area as part of phase I and II sampling rounds of 1,500 properties, a confirmation sampling round of 55 properties, and an intensive sampling round focused on 8 properties. High arsenic levels in soil can be found at certain properties in the study area. Possible exposure to arsenic in soil occurred and continues to occur at certain properties that is a concern for preschool children with soil pica behavior. In addition to these properties, past exposure to high arsenic levels may have occurred at 18 properties before EPA stopped exposure in 1998 by removing contaminated soil. Possible exposure to arsenic at the properties mentioned might cause serious health effects in preschool children with soil pica behavior. The most likely signs and symptoms in these soil pica children from eating soil with high amounts of arsenic could be nausea, stomach cramps, vomiting, and diarrhea. For soil pica children at these contaminated properties where this behavior occurs several times a week, other possible signs and symptoms might include:

- swelling of the skin around the eyes,
- eye irritation,
- redness around the eyes,
- headache,
- laryngitis,
- sore throat,
- rapid heart beat,
- severe nose bleeds,
- liver damage, and
- lowered white blood cells.

For these properties, adults and children with typical soil intake levels who live on or visit those properties are not likely to experience non-cancerous harmful effects from arsenic in soil.

This possibility of harmful effects in soil pica children applies only to a limited number of where exposure occurred in the past and is known to be currently happening and to the 18 properties that were cleaned up by EPA in 1998. Insufficient information exists to determine the public health significance of most of the other properties sampled during the phase I and II investigation. EPA, however, is currently evaluating 3,000 properties as part of its phase III soil investigation and has stated that it plans to resample many of the original 1,500 properties. Therefore, additional information about arsenic and lead contamination will be available in 2000. Personal communication from EPA's project manager for the VBI70 site indicates that preliminary soil data on the 3,000 properties shows that many properties have arsenic levels below 20 ppm. ATSDR will evaluate the public health significance of any new soil data and other environmental information when EPA makes them available.

ATSDR is also concerned about many of the 63 properties that were part of the confirmation sampling round and the intensive sampling round because of high levels of arsenic and the possibility of cancer. Adults and children who live on the most highly contaminated yards have estimated exposure levels to arsenic that are similar to exposure levels in human studies that have been shown to cause cancer in people. It is not possible at this time to determine the cancer risk for most of the 1,500 properties in the VBI70 study that were part of phase I and II sampling rounds. EPA's phase III soil investigation, which will be available in 2000, will provide sufficient information to estimate the potential cancer risk for residents who live on the properties sampled.

ATSDR is also concerned about preschool children who lived in certain properties with high levels of lead. Several of the 63 properties from the confirmation sampling round and the intensive sampling round have elevated levels of lead in surface soil. The four properties with the highest average lead levels were cleaned up by the EPA in 1998 along with several other properties with elevated lead levels in soil. Exposure from contact with lead-contaminated soil at the more highly lead-contaminated properties before they were cleaned up in 1998 might

have increased blood lead levels in some preschool children in the past and might have caused harmful effects involving the brain and nervous system. Possible effects include decreased intelligence, developmental delay, decreased stature, altered vitamin D metabolism, changes in blood enzyme levels, and decreased hearing.

Several data gaps exist in determining the extent of soil lead levels in the study area. The intensive sampling round identified several adjoining properties with high levels of lead in soil. Because of the limited sampling of these adjoining properties in the intensive round, it is not possible to determine whether or not lead in soil at those properties could harm children's health. As for the 1,500 properties sampled in phase I and II, most properties do not have sufficient number of soil samples to determine whether or not lead levels are safe or harmful for children. EPA's phase III soil data should provide information on 3,000 properties that will allow ATSDR to evaluate the possibility of harmful effects from exposure to lead in soil.

The distribution of lead in and around the VBI70 study area shows that lead contamination might exist south and west of the study area. In addition, significant soil lead contamination might exist in the central industrial area inside the study area. Since no pattern was obvious for arsenic contamination, properties outside the study area could have significant levels of arsenic in soil.

ATSDR has made several recommendations to federal, state, and local agencies to protect public health. Some of the recommendations include:

- ATSDR recommends that EPA collect soil samples from all the properties sampled in Phase I and II and measure for arsenic and lead.

- ATSDR recommends that EPA collect surface and depth samples from the area around the former Omaha-Grant smelter.

- ATSDR recommends that EPA collect surface soil samples south of the study area, that is, south of Martin Luther King Boulevard and Blake Street; west of the study area, that is, Fox Street; and east and southeast of the Clayton neighborhood.

- ATSDR recommends that EPA collect surface and depth sediment samples from drainage ways in and around the VIB70 study area and from the South Platte River if that river was not adequately characterized for arsenic and lead as part of the ASARCO Globe Plant Site.

- ATSDR recommends that the Exposure Investigation Section in ATSDR conduct an exposure investigation to determine if residents who live on properties with high levels of soil arsenic are being exposed.

- The Division of Health Education and Promotion in ATSDR will evaluate the VBI70

site for possible health education and promotion activities. This process will include an evaluation of the health education activities that have been conducted to date and an assessment of the site for possible health education and promotion activities based on this evaluation.

ATSDR has developed a public health action plan for the VBI70 site. The purpose of the public health action plan (PHAP) is to ensure that this public health assessment goes beyond presenting ATSDR's conclusions and recommendations about public health issues at the VBI70 site. The PHAP describes actions during the health assessment process that were taken to protect public health as well as actions that are planned. The PHAP at the VBI70 site involves two areas: health education activities and medical testing. Some initial activities concerning health education have been conducted. They include creating two fact sheets on gardening and holding an availability session for residents to answer their questions about gardening. ATSDR and the Colorado Department of Health and Environment (CDPHE) are also currently working on other health education activities. For instance, CDPHE is writing a letter to local health care providers to inform them of the public health issues at the VBI70 site. The health agencies are also looking at whether or not to develop other health education activities for site. In regards to medical testing, ATSDR will measure urinary arsenic levels in children and adults who live at properties with high arsenic contamination in soil. This exposure investigation will take place in the spring or summer 2000 and will be used to decide future public health actions for the site.

Based on the information presented in this document and the additional environmental information EPA, ATSDR and others will collect, ATSDR will decide what future public health activities the Agency will conduct at the VBI70 site.

Purpose and Health Issues

Purpose

Through public health assessments, the Agency for Toxic Substances and Disease Registry (ATSDR) evaluates the public health significance of possible exposure to contaminants at Superfund sites, and then decides what public health activities are needed. These activities generally fall into the following broad categories: evaluation of human exposure to contaminants; medical tests; health education; health promotion; recommendations to local, state, and federal agencies; community involvement; and health studies. This public health assessment describes ATSDR's activities at the Vasquez Boulevard and I-70 (VBI70) site and provides the Agency's opinion about the public health significance of contamination at VBI70.

To investigate this site, ATSDR established the "VBI70 Health Team," hereafter referred to as the health team. Since January 1999, the health team has met regularly to discuss public health issues related to the VBI70 site. Input from team members has been invaluable to ATSDR, and has helped the Agency evaluate chemical exposures and decide what public health activities are appropriate.

Listed below are the health team members:

Ms. Sandra Coulberson	ATSDR, Atlanta
Ms. Sandy Douglas	Cole neighborhood resident, Denver
Mr. Ted Fellman	U.S. Environmental Protection Agency, Denver
Ms. Lorraine Granado	Swansea neighborhood; Executive Director, Cross Community Coalition, Denver
Dr. David Hewitt	ATSDR, Atlanta
Ms. Joan Hooker	Clayton neighborhood, Denver
Mr. Michael Maes	Swansea neighborhood, Denver
Dr. David Mellard	ATSDR, Atlanta
Ms. Melissa Muñoz	Colorado People's Environmental & Economic Network (COPEEN), Denver
Ms. Susan Muza	ATSDR, Denver
Ms. Theresa NeSmith	ATSDR, Atlanta
Dr. Lourdes Rosales-Guevara	ATSDR, Atlanta
Dr. Myron Schultz	ATSDR, Atlanta
Ms. Nancy Strauss	Colorado Department of Public Health and Environment, Denver
Ms. Julia Korndoffer	Colorado Department of Public Health and Environment, Denver
Mr. Anthony Thomas	Clayton neighborhood, Denver
Mr. Michael Wenstrom	U.S. Environmental Protection Agency, Denver
Ms. Celia VanDerLoop	City and County of Denver Health Department, Denver

Public Health Issues

During its investigation of the VBI70 site, ATSDR and the health team identified the following public health issues that were to be investigated as part of the public health assessment process:

1. Is arsenic contamination in soil a threat to the public's health?

2. Is lead contamination in soil a threat to the public's health?

3. Is exposure to other chemicals in the environment (e.g., in the air) a threat to the public's health?[1]

4. Are communities of color at increased risk of harmful effects from lead and arsenic exposure?[2]

Background

Introduction to the Site

The VBI70 site spans approximately 450 acres in northeast Denver (see Appendix A, Figure 1). It includes the area that the U.S. Environmental Protection Agency (EPA) has proposed to the National Priorities List (NPL),[3] as well as an expanded study area (see Appendix A, Figure 2).[4] EPA proposed adding VBI70 to the NPL on January 19, 1999, thus requiring ATSDR to conduct a public health assessment by January 19, 2000.

As Figure 2 shows, the study area is a complex shape, and is located primarily southeast of the interchange of Interstate 25 and Interstate 70. The study area does not extend further east than Colorado Boulevard, further south than Martin Luther King Boulevard, further north than 52nd Avenue, and further west than the Burlington Northern rail tracks west of Interstate 25. Figure 2 also shows that the VBI70 study area includes all or part of the following five Denver neighborhoods: Clayton, Cole, Elyria, South Globeville, and Swansea. This area includes a mix of residential, commercial, and industrial sections.

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[1] This question will be answered in the public health assessment's draft release for public comment in Spring 2,000..

[2] This question will be answered in the public health assessment's draft release for public comment in Spring 2,000.

[3] EPA's NPL is a list of hazardous waste sites that appear to need some kind of remedial action to stop exposure to toxic chemicals or radiation.

[4] The boundaries of the NPL site and the study area shown in Figures 1 and 2 are based on maps that EPA provided to ATSDR.

More detailed information about pollution sources in and near the VBI70 study area can be found later in this "Background" section, under the headers "Area History" and "EPA's Regional Geographic Initiative (RGI)."

Area History

Based on the information summarized in this document, there is evidence of contaminated soil around the VBI70 study area. Soils in the study area could have been contaminated by many activities. Many industrial activities currently take place in and around the study area. In addition, two smelters used to operate and a third smelter still operates in the area. Some information about these smelters follows:

- *The Omaha-Grant smelter.* As Figure 1 shows, the Omaha-Grant smelter was located south of Interstate 70, west of Brighton Boulevard. The smelter operated at this location from 1882 to 1903. During this time, it processed 2,200,000 tons of ore and produced gold, silver, copper, and lead according to government reports. In 1899, the Omaha-Grant smelter became part of the American Smelting and Refining Company (ASARCO), which continued to operate the plant until it closed in 1903. The Omaha-Grant smelter stack was used by the City of Denver as a municipal waste incinerator from 1944 to 1950. The City demolished the smelter stack shortly thereafter and covered part of the area with concrete, asphalt, and the Denver Coliseum (Apostolopoulos 1998, ATSDR 1995).

- *The Argo smelter.* As Figure 1 also shows, the Argo smelter was located near the current interchange between Interstate 25 and Interstate 70. This smelter operated from 1879 to 1910. It produced gold and silver by roasting copper ore and matte.[5] The Argo smelter no longer exists.

- *The Globe smelter.* The Globe smelter is located less than 1 mile north of I-70, between Washington Street and I-25. The smelter first began operating in 1886, and was purchased by ASARCO in 1899. The operations at this site have changed many times over the years, and the smelter, at one time or another, has produced gold, silver, copper, lead, cadmium, arsenic, indium, selenium, antimony, and other metals. Present day operations at the Globe plant are different from historic operations. Only a few buildings at the plant are currently in use for the production of bismuth products,[6]

[5] Matte is a product that has a sulfur containing metal. Common examples are copper matte and nickel matte.

[6] Bismuth is a metal like lead and arsenic and is used in making pharmaceutical products (for example, Pepto Bismol). It is also used in industrial processes.

litharge,[7] highly purified lead, and tellurium.[8] Small amounts of highly purified "specialty metals" are also produced. Specialty metals produced during the last year include cadmium telluride, cadmium sulfide, lead telluride, zinc telluride, and high purity copper cylinders.

Other industrial activities may have also contributed to soil contamination in the study area. Those activities are presented in the Regional Geographic Initiative section. In addition to industrial activities, arsenic containing pesticides and herbicides were frequently used in the U.S. during the 1950's and 1960's. The extent to which these sources or activities have affected VBI70 study area soils has not been determined. EPA is currently investigating possible sources of arsenic and lead contamination.

Actions Taken by EPA to Stop Exposure to Arsenic and Lead

After sampling soil in people's yards, EPA offered to clean up the most contaminated properties in the VBI70 study area. This decision was made to stop residents from coming into contact with potentially harmful levels of arsenic and lead. During this clean-up project, EPA considered properties with average soil arsenic levels above 450 ppm or average soil lead levels above 2,000 ppm to be eligible for cleanup at no cost to the property owner. As of today, EPA has cleaned up 18 of the 21 properties that had soil contamination above the cleanup levels; owners of the other 3 properties refused EPA's cleanup offer.

Information from EPA's Regional Geographic Initiative

In 1989, EPA reported that the Denver zip code 80216, which includes the neighborhoods of Swansea, Elyria, and South Globeville, has the second highest industrial emissions of hazardous pollutants in Denver (EPA 1989). In 1989 alone, more than 331,000 pounds of toxic chemicals were legally released to the air, water, and soil within this zip code. In 1995, 80216 again had the second highest emissions in Denver, and chemical releases reportedly increased to more than 771,000 pounds (EPA 1995a).

Concerned about these releases, the Cross Community Coalition (CCC), a grassroots community organization located in Swansea, applied for and received a grant in 1998 from EPA under the Regional Geographic Initiative (RGI) to study local pollution problems. Under this grant, a group of residents, industry representatives, large and small business representatives, a church representative, and staff members from federal, state, and city government have worked to identify:

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[7] Litharge is an oxide of lead made by heating metallic lead.

[8] Tellurium is a nonmetallic element similar to sulfur. It has a number of industrial uses, for example, as part of stainless steel and iron castings as well as a coloring agent in glass and ceramics.

- sources of pollutant emissions (both TRI[9] and non-TRI in the 80216 zip code),
- types of pollution emitted,
- potential health risks related to the pollution, and
- actions needed to protect residents' health.

What follows is a preview of some findings from this stakeholder group. For greater detail, see Tables 1 through 5 in Appendix E. The location of TRI facilities in and around the VBI70 study area is shown in Appendix F, Figure 11.

Sources of pollution within the 80216 zip code include the following:

- vehicles—781 million vehicle miles were traveled in 1998 on Interstate 70 and other major traffic routes within the zip code (CDPHE 1999a),
- bakeries,
- manufacturing facilities,
- large-volume and small-volume printers,
- metalworking shops,
- autobody and truck repair shops,
- petroleum refineries, and
- a major electric utility power plant that burns low-sulfur coal (CDPHE 1999b).

The 80216 zip code is also home to 38 diesel truck fleets.[10] Combined, these fleets contain more than 4,800 trucks (CDPHE 1999c). In addition, some businesses in the area—including a rendering plant and a Purina pet food plant—emit very strong odors (see Appendix F, Figure 11).

Reviewing reports from facilities that are required to disclose air emissions to CDPHE's Air Pollution Control Division revealed more than 50 substances released into the air each year in the 80216 zip code (CDPHE 1999b). The substances emitted in largest quantities are listed below:

[9] TRI is the Toxic Release Inventory, a database of environmental releases maintained by EPA. Only selected industries, and facilities within these industries, are required to report releases to TRI. Therefore, it is not a comprehensive account of environmental releases.

[10] A fleet of trucks is defined as a group of more than nine trucks owned by a company.

- sulfur oxides,
- nitrogen oxides,
- carbon monoxide,
- very-small-diameter particulate matter (PM_{10} and $PM_{2.5}$),
- numerous organic compounds,
- hazardous air pollutants, and
- inorganic metals, such as lead and arsenic.

The truck fleets and the interstate traffic are sources of particulate matter (primarily road dust and soot), hydrocarbons, nitrogen oxides, sulfur dioxide, carbon monoxide, and formaldehyde (CDPHE 1999d).

There are four other NPL sites in or near the VBI70 study area (see Appendix F, Figure 11):

- the ASARCO Globe Plant,
- Sand Creek Industrial,
- Chemical Sales Company, and
- Broderick Wood Products.

There are also numerous facilities that are required to have permits under the Resource Conservation and Recovery Act (RCRA) to either generate, transport, or store hazardous waste. Some examples of RCRA facilities are Koppers (Beazer East Inc)., Woodbury Chemical, RAMP Industries, Amoco Oil, and Conoco Denver Transport Terminal, to name a few (see Appendix F, Figure 11) (EPA 1999d).

Timeline of ATSDR Activities

ATSDR became involved with the VBI70 site in November 1998. One of ATSDR's first actions was putting together the health team. The health team, in turn, has planned several public health activities for the site, and has set a schedule for completing them. As of today, some of the planned activities have been carried out while others have yet to be completed. Figure 3 in Appendix B lists the activities that have been completed, as well as those ATSDR expects to complete.

ATSDR's public health assessment process—an important activity for the VBI70 site—involves several activities. First, ATSDR evaluates all relevant environmental data, community

concerns, and sometimes health outcome data for a site. The results from this first activity are then used to determine the other activities needed, such as medical testing, health education, and health promotion. This public health assessment focuses on evaluating environmental data and community concerns as well as health education activities that took place during the investigation. As decisions are made from evaluating environmental data, community concerns, and medical tests at the VBI70 site, other activities may take place in the future. As additional environmental data become available, other activities may take place in the future.

CDPHE Investigations

As a follow up to investigations at the nearby ASARCO Globe Plant Site, the CDPHE on July 16, 1997, collected 25 soil samples, 3 surface water samples, and 3 sediment samples from what is now the VBI70 study area. The samples were analyzed in a lab for levels of inorganic metals, such as arsenic, cadmium, and lead. The soil samples were collected in Elyria (23 samples) and Swansea (2 samples). Overall, arsenic levels in residential yards were as high as 1,300 parts arsenic for every million parts of soil (abbreviated as ppm) and lead levels as high as 660 ppm (Apostolopoulos 1998; EPA 1998a). These levels are much higher than the amounts of arsenic and lead that naturally occur in soil in the Denver area. The finding of elevated levels of arsenic and lead prompted EPA to conduct more extensive soil sampling in the five neighborhoods that eventually became the VBI70 study area.

EPA Investigations

EPA has conducted several environmental investigations at the VBI70 site. This section describes those investigations, as well as other EPA investigations that are involved with ATSDR's public health assessment process:

- *Phase I and II sampling.* In the spring and summer of 1998, EPA conducted what it called "Phase I" and "Phase II" soil sampling at the VBI70 site. During these sampling efforts, EPA collected soils from roughly 1,500 properties in the study area. At each property, EPA generally took two samples of surface soils (from the top 2 inches of soil) and one sample of soil from below the surface (from deeper than 6 inches). This sampling identified many properties with potentially high levels of arsenic and lead in soils.

- *Confirmation sampling.* Based on the results of phase I and II soil samples, EPA went back to 55 properties with some of the highest levels of contamination to collect additional soil samples. This "confirmation sampling" took place as part of phase II sampling rounds in summer and possibly fall 1998. Most of the samples that were collected are called "five-point composite samples," which means that soils from five different locations on a property were collected and mixed together. The results of the confirmation samples were used to decide which properties required immediate cleanup at no cost to the property owner. Of the 55 properties considered, 21 met EPA's criteria for cleanup. That is, 21 properties had average arsenic levels in soil above 450

ppm or average lead levels in soil above 2,000 ppm, or both.

- *Intensive sampling.*[11] In addition to collecting the confirmation samples, EPA conducted what it has called "intensive sampling" in summer and possibly fall 1998 at eight properties in the study area. Some of the properties were selected because they had extremely high levels of arsenic or lead in the soils while others were selected because they had low levels of arsenic or lead in the soils. As part of this sampling effort, EPA collected soil samples from throughout the selected properties, and on some of the neighboring properties. Through this approach, the intensive sampling collected as many as 224 soil samples from each of the eight focus properties, thus providing a very detailed picture of contamination at those properties. Since EPA collected soil samples up to 15 feet into some neighboring properties, the intensive sampling effort provided information about contamination at the property line with neighboring properties.

- *Phase III sampling.* In the fall and winter of 1999, EPA conducted what has been called "Phase III" sampling. During this study, EPA collected surface soil samples from approximately 3,000 properties that were not sampled during phases I and II. EPA used a different sample design during phase III to better estimate the average concentration of arsenic and lead at each property. The new sample design consisted of collecting 3 composite soil samples from each property, with each composite consisting of 10 individual soil samples. EPA also collected indoor dust samples from some properties (EPA 1999b). No data from phase III was available to ATSDR when this report was released on January 19, 2000.

- *Other studies.* In addition to the many soil sampling studies, EPA has also studied how contaminated soils react in pigs. Specifically, EPA has fed pigs arsenic-contaminated soil from yards in the VBI70 study area to determine how much arsenic the pigs would absorb from their stomach and intestines into their body. EPA plans to use this information to estimate how much arsenic will be absorbed by people who come into contact with arsenic-contaminated soil (EPA 1999c). In addition, EPA conducted studies on the arsenic and lead in soil to determine the chemical form of arsenic and lead are present in soil (EPA undated).

Demographic Information

When reviewing available environmental information, ATSDR considers the number and makeup of the population in the surrounding area. For the VBI70 site, ATSDR reviewed the demographic information of different groups of people in the study area:

- *Demographics of the VBI70 study area.* According to 1990 census data, 13,350 people live in the VBI70 study area—an area with 5,500 housing units. As shown in Appendix

[11] The intensive sampling round is also referred to as the risk-based sampling in some EPA documents.

C, Figure 4, the racial composition of the area is diverse: 26% of the population (3,521) is white, 34% (4,492) is black, and about 38% (5,031) report a race other than those listed. The "other race" category includes people who identified themselves in the census as multiracial, multiethnic, or of Hispanic origin. In response to a separate question on the census, approximately 7,000 people in the study area identified themselves as being of Hispanic origin. Thus, about 60% of the people in the study area are Hispanic and about 30% are African-Americans.

Information on potentially sensitive populations, such as young children and older adults, is also presented in Appendix C, Figure 4. Children 6 years old or younger make up 13% (1,800) of the population, and approximately 12% (1,562) of the population is 65 years of age or older.

- *Demographics of the proposed VBI70 NPL site.* Appendix C, Figure 5, shows population information about the people who live within the boundaries of the proposed VBI70 NPL site, which covers less area than the VBI70 study area. Approximately 5,800 people live in the proposed NPL site boundaries, with a racial composition somewhat similar to that of the population residing with the VBI70 study area.

- *Demographics of neighborhoods within the VBI70 study area.* Appendix D, Figures 6 through 10, show the same type of population information for each of the five neighborhoods that make up the VBI70 study area: Clayton, Cole, Elyria, South Globeville, and Swansea.

The previous demographic information is based on data reported in the 1990 census. More recent census data are not available, but estimates of the population demographics in the years 1998 and 2003 are available. Information on these estimates for the VBI70 study area is presented in Appendix D.

Environmental Data and Contaminants of Concern Requiring Further Evaluation

EPA provided ATSDR with an electronic database of the phase I and phase II soil sampling data. This database contained soil measurements from 1,412 properties and consisted of 4,698 records. EPA also provided an additional 442 records of confirmation sampling data and 1,667 records of intensive sampling data. ATSDR's evaluation of the public health significance of contamination at the VBI70 site is based on those environmental data. EPA is currently collecting phase III soil sampling data, and those data were not available for review when this report was written.

During all of EPA's sampling efforts, levels of arsenic, lead, and other metals were measured using what is called an "X-ray fluorescent" (XRF) instrument. In addition, 10% of the soil samples were measured using a method called "inductively coupled plasma (ICP) spectroscopy." The ICP measurements were used to check to make sure that the XRF measurements were accurate.

Arsenic

According to the XRF results from EPA's phase I and II soil samples, about 500 properties had at least one soil sample with arsenic levels above 58 ppm. The remaining 900 properties had arsenic levels below the XRF instrument's detection limit, which varied from 44 to 57 ppm. These 900 properties either had background levels of arsenic in their soils (approximately 7 ppm[12]) or low amounts of arsenic (levels between 7 ppm and the detection limit). However, for phase I and II results, the XRF method was not sensitive enough to measure arsenic levels between 7 and 57 ppm.

In addition to the EPA data collected specifically for the VBI70 site, CDPHE collected 25 soil samples from Elyria and Swansea in July 1997. Of the 25 properties tested, 12 properties had elevated arsenic levels, with the highest level being 1,800 ppm (Apostolopoulos 1998).

Lead

EPA's XRF results from phase I and II soil samples showed that most of the properties contained detectable levels of lead. The typical detection limit for the XRF instruments used by EPA was about 30 ppm, meaning that the instrument usually could not detect lead below that level. That detection limit is close to 20 ppm, the typical background level of lead in naturally occurring soils in the western U.S. (ATSDR 1992). It is not unusual, however, for soil in urban and suburban areas to be contaminated with lead at several hundred parts per million, due to lead fallout from the historical use of leaded gasoline in cars as well as from other sources. Many properties had elevated levels of lead in soil, however, only a few properties had lead levels in soil that were a health concern.

Cadmium

During phase I and II sampling, EPA planned to use XRF instruments to measure levels of cadmium in soil. These measurements, however, were often found to be inaccurate. As a result of this problem, EPA has reported that the XRF cadmium measurements from the phase I and II sampling are not valid.

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[12] In a survey of U.S. western soils, the background level was determined to be 7 ppm with the highest detected level in all samples being 97 ppm. (ATSDR 1992). Since 7 ppm is an average, half the values are below 7 and half the values are above 7. What is in question here is the distribution of the values above 7 ppm and whether arsenic levels of 20, 30, 40, or 50 ppm can be considered the upper end of background levels for arsenic in Denver. ATSDR has not located reliable information specifically for Denver, nor has EPA generated a background arsenic soil level specifically for the VBI70 site. One study has reported that the upper limit of "background" level of arsenic at the Globe smelter is 28 ppm because two peaks were seen when the soil data was plotted (TRC Environmental Consultants 1992). ATSDR does not believe this value is reliable, because elevated levels of arsenic were detected both on and off the site. In addition, historical smelter emissions and other possible sources in northern Denver might have raised background levels. Therefore, assuming that the lower peak represents background levels of arsenic could be a mistake. It is not certain, therefore, whether or not the 28 ppm arsenic level is a true upper limit for arsenic background levels for the entire northern Denver area. Because of these limitations ATSDR cautions against using 28 ppm as an upper limit of background arsenic levels.

Although the XRF measurements of cadmium were unsuccessful, EPA sent 363 soil samples from its phase I investigation to a laboratory for analysis using the ICP chemical method. Those results, which were found to be accurate and valid, show the average cadmium levels from the VBI70 study area to be 5 ppm in surface soil and 5.6 ppm in subsurface soil. The highest level reported was 37 ppm, from a subsurface soil sample (EPA 1998b). These levels are higher than what has been reported as the background level of cadmium in naturally occurring western soil, 0.07 to 1.1 ppm (Kabata-Pendias 1984).[13]

While soil cadmium levels appear to be higher than background levels, the level of cadmium in soil will not cause harmful effects to people in the VBI70 study area. The estimated amount of exposure to adults and children from contact with soil is below ATSDR's Oral Minimal Risk Level (MRL) for cadmium and below EPA's Chronic Reference Dose (RfD) for cadmium.[14] For this reason, this health assessment report contains no further evaluation of the harmful effects of cadmium from soil.

Other Contaminants of Concern

Soil contains many inorganic metals with a range of naturally occurring levels. Pollution from industrial sources and other types of activity can increase the level of metals in soil. During phase I, EPA analyzed 44 soil samples for the metals that are most commonly found in soil. Most of these samples came from Swansea and Elyria. Except for arsenic, lead, cadmium, and zinc, the levels of inorganic metals in the 44 soil samples from VBI70 are similar to the levels in soil from the western U.S. The arsenic, lead, and cadmium contamination was reviewed in the previous discussion, and the zinc contamination is reviewed below.

The levels of zinc in surface soil at VBI70 ranged from 84 to 1,600 ppm, with an average level of 629 ppm; the levels of zinc in subsurface soil ranged from 84 to 3,300 ppm, with an average of 406 ppm. These levels are considerably higher than the average level of zinc found in naturally occurring soils in the western U.S., which is 65 ppm. In an earlier site investigation at the ASARCO Globe Plant Site, zinc was also found at elevated levels in soil.

The levels of zinc in soil in the 44 samples are not high enough to cause harmful effects in people. The estimated amount of exposure to zinc for children and adults from contact with soil is below ATSDR's oral MRL for zinc and EPA's chronic RfD for zinc. In addition, zinc is a nutrient, or an essential element for humans, and the National Academy of Sciences has recommended that the American diet contain 10 to 15 milligrams of zinc per day. Health effects from exposure to zinc in soil will not be evaluated in this report.

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[13] Urban areas often contain higher levels of cadmium because of automobile traffic and possible local industrial sources. A survey by Skyline Labs, Inc., found a geometric average cadmium level in soil of 2.2 ppm in the metropolitan Denver (Skyline Labs 1986).

[14] MRLs and RfDs are health guidelines designed to identify exposure levels in humans below which harmful effects are unlikely.

Thallium is another naturally occurring metal in soil. In EPA's phase I investigation, thallium was detected in the study area at an average level of 13 ppm in surface soil samples and 15 ppm in subsurface soil samples. Subsequent analysis by EPA using two other methods showed that thallium levels in soil were below 1 ppm and that the XRF instrument was probably overestimating thallium levels in soil. The thallium levels measured by the two other chemical methods are similar to background levels of thallium in naturally occurring soil (ATSDR 1992). These background levels of thallium are not harmful to people. As a result, thallium will not be evaluated further in this public health assessment.

Adequacy of the Environmental Data

When reviewing the soil sampling data for this site, ATSDR first reviewed the data from different environmental investigations to determine whether they were adequate for making public health decisions. Below is a summary of ATSDR's review of the adequacy of the surface soil sampling data for the VBI70 site.

Phase I and II Samples

During the phase I and II sampling rounds, EPA generally collected at least three soil samples (two surface and one subsurface) at every property that was considered. The two surface soil samples characterize levels of contamination at two particular points at each property, but they might not provide an accurate measure of property-wide levels of contamination, especially at residences where levels of contamination change significantly across the property.

In fact, comparison of the Phase I and II data with the more extensive data collected during the confirmation and intensive sampling has showed some startling differences in the levels of contamination at selected properties. This suggests that the Phase I and II sampling did not provide a complete account of soil contamination in some cases. The confirmation sampling and intensive sampling likely are more representative of soil contamination, since they consisted of many more samples at every property, as was discussed earlier in this report.

Intensive and Confirmation Samples

As noted previously, EPA's intensive and confirmation sampling efforts measured contamination in soils at several locations on a property, instead of measuring contamination at just one or two locations. Therefore, these sampling efforts provide a much more accurate account of contamination at the VBI70 site. As a result, ATSDR's public health decisions for this site were drawn primarily from the results of the intensive and confirmation sampling, and less so from the Phase I and II sampling. More details on this decision follow:

- *Intensive sampling.* During EPA's intensive sampling, soils were collected at 5-foot intervals at eight residential properties in the VBI70 study area. Additionally, EPA collected soil samples, when possible, as far as 15 feet into the properties that adjoin the eight properties. The purpose of the intensive sampling effort was to characterize the distribution of arsenic and lead in both contaminated and non-contaminated yards,

and in their adjoining properties. Between 89 and 224 soil samples were collected at the eight properties that were the focus of the intensive sampling effort. Therefore, the intensive soil sampling data are sufficient to make public health decisions for these properties. The limited sampling of adjoining properties did not provide sufficient information to characterize long-term exposure but did provide limited information when evaluating very short-term exposure in children.

- *Confirmation sampling*. At 55 properties, EPA conducted confirmation samples. As noted earlier, most of the confirmation samples were actually "five-point composite samples," in which soils from five locations were gathered and analyzed as one sample. A composite sample was collected from the back yard and front yard of every property considered in this sampling, and discrete soil samples were collected in selected side yards and gardens. Therefore, the confirmation sampling effort characterized levels of contamination at many locations at each property, thus providing a useful indicator of the property-wide contamination.

It should be noted that five properties were part of both the confirmation and intensive sampling efforts, enabling ATSDR to compare the results for these two sampling approaches. In general, the two sampling schemes provide somewhat similar results. There are some exceptions though, which shows that the intensive sampling scheme provides a better estimate of property-wide contamination than the 5-point composite scheme. Because five-point composites might miss significant areas of contamination, the confirmation results are less reliable in making public health decisions compared to the intensive sampling.

Phase III Soil Samples

Phase III soil sample results were generated by collecting three 10-point composite samples from each property. This approach will be sufficient for making public health decisions about exposure to contaminants in soil, but the phase III soil sampling results were not available at the time this report was released on January 19, 2000.

AIRS Data

The Aerometric Information Retrieval System (AIRS) is a publicly accessible database of information about air pollution in the United States. EPA has many uses for AIRS, but the database's main use is to track changes in air quality across the country. The information in AIRS comes primarily from states, which are required to submit air quality measurements to EPA for certain pollutants. As no exception, the state of Colorado routinely provides summaries of its air quality measurements to EPA, and these results are then loaded in AIRS. Currently, AIRS has extensive air quality data for more than 20 ambient air monitoring stations throughout the Denver metropolitan area, thus providing extensive information about this area's air quality for certain pollutants.

According to EPA, air quality throughout the Denver metropolitan area currently meets the attainment criteria for lead, nitrogen dioxide, and sulfur dioxide. All of Denver County and parts of Adams County currently are not in attainment with EPA's National Ambient Air Quality Standard for particulate matter. Similarly, all of Denver County and parts of Adams County currently are in "serious non-attainment" with EPA's carbon monoxide standard.

Technically, the 1-hour standard for ozone has not applied to the Denver metropolitan area since May 1998. Rather, this area is in the process of determining whether it meets EPA's recently promulgated 8-hour standard for ozone. This determination will not be made until some time next year (i.e., calendar year 2000). However, prior to 1998, all of Denver county and parts of Adams county were not in attainment with the 1-hour ozone standard.

Discussion

This section presents ATSDR's analyses of public health issues at the VBI70 site. Using information from many different sources, this section addresses several important topics, such as how people might be exposed to contaminants, how much exposure may occur for the different contaminants, what situations and human activities must exist for exposure to occur, and what harmful health effects might occur as a result of their exposures. This section focuses on people who live in the VBI70 study area, where soil samples and other types of samples have been collected.

The information presented in this section also answers the many questions that community representatives from the VBI70 study area asked ATSDR about contamination at their properties and describes the health education and promotion activities that took place during the health assessment process.

Completed Exposure Pathways

When reviewing sites to determine the possibility of contamination, one of ATSDR's first goals is to identify what it calls "exposure pathways." Exposure pathways are different ways that contaminants move in the environment and the different ways that people can come into contact with chemicals, such as breathing them in (inhalation) or accidentally drinking or eating them (ingestion). A "completed exposure pathway" exists when information exists that shows a contaminant to be in soil, water, or air that residents have come into direct contact with in the environment, either in the past, the present or likely will do so in the future. ATSDR has identified two completed exposure pathways for the VBI70 site, as described below.

Soil Ingestion for children and adults

The most important exposure pathway at the VBI70 site is accidental ingestion of contaminated soil and household dust, by both children and adults. This exposure occurs when people interact with soils in their environment. For instance, when children play outside or crawl on floors or when adults work in yards and gardens, contaminated soil or dust particles cling to their hands. Residents can then accidentally swallow the contaminants when they put their hands on or into

their mouths, as children often do. Since people and pets track contaminated soils from outdoors into their homes, exposures can occur both while people are in their homes and while they are in their yards. Unless contaminants are removed from properties, some residents will be exposed to contaminated soils and dusts as long as they live in the VBI70 study area. The contaminants of greatest concern for soil ingestion are arsenic and lead.

The amount of chemicals to which people are exposed depends on many factors, such as the levels of contamination at their homes: The highest amount of exposure is expected to occur among people who spend time at the homes with the highest levels of soil contamination. The people who live at these homes will probably have the most exposure, but neighbors who visit these homes can also be exposed, but to a lesser degree. For reasons described below, preschool children, whether they live at homes with contaminated soils or frequently visit homes with contaminated soil, are most likely to have the highest levels of exposure. On the other hand, adults and older children who visit houses with contaminated yards probably have little or no exposure.

Another factor that greatly affects people's exposures is the amount of soils they accidentally ingest on a daily basis. Though people might not be aware of this, everyone ingests some soil or dust every day, but some people tend to swallow more soil or dust than others. Preschool children, on average, swallow more soil and dust than people in any other age group. This is because preschoolers often have close contact with soil and dust when they play and because they frequently engage in hand-to-mouth activity. Children in elementary school, teenagers, and adults are also exposed to dusts and soils, but generally in much smaller amounts.

When evaluating exposures, ATSDR considered a wide range of human activities. The most important is preschool children who eat large amounts of soil. The reasons why some children engage in this behavior, which is called "pica" behavior, is not known. Scientists have suspected that pica behavior has something to do with nutritional deficiencies, psychological needs, and cultural factors (Danford 1982), but none of these links have been proven. Pica behavior is most likely to occur in 1- and 2-year old children, but it can occur in older children and even in adults. The exact number of children who go through a stage of pica behavior is not known. Studies have reported that this behavior occurs in as few as 4% of children or in as many as 21% of children (Barltrop 1966, Robischon 1971, Shellshear 1975, Vermer and Frate 1979).[15] Using statistics, two scientists have estimated as many as 33% of preschool children will have soil pica behavior once or twice during their preschool years (Calabrese and Stanek 1998). They admit, however, that their 33 percent may overestimate the percentage of children with 1 to 2 days of soil pica behavior.

In addition to the potentially exposed people listed above, some workers in the VBI70 study area might accidentally come into contact with contaminated soils. As an example, contractors and utility workers might work on job sites with contaminated soils. If these workers were to get the soils onto their hands, and then engage in hand-to-mouth activity, they too could be exposed to

[15] This means that as few as 4 or as many as 21 out of every 100 children might have soil pica behavior.

the contaminants in the area.

ATSDR carefully evaluated the many different ways that people in the VBI70 study area can come into contact with contaminated soils, and the public health implications of this contact. More information on the public health significance of the contaminated soils is presented later in this report.

Eating home-grown produce

Another way people in the VBI70 study area can come into contact with contaminants is by eating fruits, vegetables, spices, or other produce grown locally in gardens that contain contaminated soil. This type of exposure occurs because many plants slowly absorb small amounts of chemicals found in soils. Some of the absorbed chemicals are essential nutrients and are actually good for humans to eat, but other chemicals can present health hazards if they are found at high enough levels and if people regularly consume the produce. For this reason, both ATSDR and CDPHE have evaluated the exposure pathway of eating home-grown produce, as summarized below.

When reviewing this pathway, ATSDR focused its evaluation on levels of arsenic in produce. The other contaminants in the VBI70 soils either are far less likely to be absorbed by plants (e.g., lead) or are much less toxic than arsenic (e.g., zinc). Using a method developed by EPA (EPA 1995b) and advice from the U.S. Department of Agriculture ATSDR and CDPHE estimated how much arsenic residents in the VBI70 study area would ingest if 30% of the produce they ate came from their home garden. This analysis found that the amount of arsenic that people might ingest by eating home-grown produce is far below the amounts that are known to cause harmful effects.

The residents of the VBI70 study area have recently received two important fact sheets with public health information about eating home-grown produce. In April 1999, while public health agencies were evaluating specific health risks for the VBI70 site, CDPHE published and released the first fact sheet, which described how garden produce can absorb soil contaminants and explained how residents can protect themselves from these contaminants. A copy of this fact sheet is presented in Appendix G. In August 1999, after public health agencies finished evaluating the risks of eating home grown produce, ATSDR published and released the fact sheet presented in Appendix H. This fact sheet informed residents that it was safe to eat fruits and vegetables from their home gardens, because the amount of arsenic that these plants absorb is likely far below levels that might harm the people who eat their produce.

Possible (Potential) Exposure Pathways

When important information about an exposure pathway is missing or incomplete, ATSDR classifies it as a possible (or potential) exposure pathway. In these cases, not enough information is available to conduct detailed analyses of the amount of exposures to contaminants in areas where people live, work, and play. ATSDR has identified three potential exposure pathways for the VBI70 site. The following discussion identifies these pathways and the missing information.

Ingesting or Touching Sediment and Surface Water

Rain water and snow melt can carry contaminants from the air and surface soil into local "surface waters," such as drainage ditches, creeks, streams, and rivers; some of the contaminants can then settle into the sediments at the bottom of these waters. People who play or work in these waters, in turn, can accidentally come into contact, or even swallow, small amounts of the contaminants in the water and sediments. Recognizing this route of exposure, ATSDR gathered and reviewed information on contamination in sediments and surface waters in the VBI70 study area, as described below.

Sediments. ATSDR identified only one study so far that measured levels of contamination in the sediments of the local surface waters.[16] This study was conducted in 1997 by CDPHE and focused on the sediments and surface water of the South Platte River—the main water way that flows through the VBI70 study area. During this study, three sediment samples were collected: one from where the river flows beneath I-70 (near the Denver Coliseum), one approximately one-half mile upstream from this location, and one approximately one-half mile downstream from this location (Apostolopoulos 1998). The samples were analyzed for concentrations of metals, including arsenic, lead, and cadmium, but none were found at unusually high levels.

For two reasons, ATSDR cannot be certain that contamination in the sediments in the VBI70 study area has not reached potentially unhealthy levels. First, the limited sampling during the 1997 study does not provide an extensive account of contamination in the South Platte River. The three samples might have been collected in areas with relatively "clean" or relatively "dirty" sediments. If so, the study's findings would not reflect levels of contamination in the sediments throughout the South Platte River. Second, ATSDR could not find sampling results for the sediments in the other surface water bodies in the VBI70 study area, such as creeks and drainage ditches. Without more sampling data, it is impossible to determine whether contaminated sediments might harm children or adults. ATSDR notes, however, that contaminated sediment would pose a health hazard only if people routinely contacted the sediments, which does not seem likely for the surface waters in the VBI70 study area, as described below.

Surface Water. ATSDR identified only one study so far—CDPHE's 1997 study, which was described above—that measured levels of contamination in the surface waters in the VBI70 study area.[17] During this study, CDPHE collected three surface water samples from the South Platte River, in the same locations where sediment were sampled (see above).

Though some contaminants have been detected in the South Platte River, the residents in the VBI70 study area rarely, if ever, come into contact with them. For exposure to occur, people would have to swim or wade in the South Platte River—an activity that presumably occurs only

[16] ATSDR is investigating whether or not studies of the South Platte River have been conducted as part of CDPHE's investigation of the nearby Globe ASARCO Plant Site.

[17] ATSDR is also investigating whether or not studies of the South Platte River have been conducted as part of CDPHE's investigation of the nearby Globe ASARCO Plant Site.

during the warmer summer months, if at all. Since arsenic and lead, the contaminants of concern at this site, do not readily pass through skin, wading in the river will likely not result in any exposure to these chemicals. To be exposed to the chemicals in the water, residents would have to swallow river water accidentally, but the likelihood of this happening is extremely low. Therefore, significant exposure to the contaminants that were detected in the South Platte River seems unlikely.

Another possible exposure occurs when residents come into contact with surface water in drainage ditches, streams, and puddles in the VBI70 study area. For the reasons stated above, however, simply coming into contact with these surface waters would not result in exposure, unless the residents actually drank from these waters, which seems highly unlikely. Because of this, it is unlikely that surface water could be a significant route of exposure for people who live in the VBI70 study area.

Drinking groundwater

The groundwater beneath the VBI70 study area has not been tested. EPA has stated that it plans to investigate potential groundwater contamination in this area at a later date. Until then, however, levels of contamination in the groundwater are not known, preventing ATSDR from fully evaluating the public health significance of potential groundwater contamination.

ATSDR notes, however, drinking water at all residences in the VBI70 study area is drawn from surface waters from the nearby Rocky Mountains. Therefore, even if the groundwater beneath the VBI70 study area were contaminated, it is highly unlikely that residents would ever drink the contaminated groundwater. Nonetheless, ATSDR will evaluate the public health significance of groundwater contamination, if evidence of contamination becomes available.

Breathing outdoor and indoor air

The contaminated soils and dusts in the VBI70 study area can become airborne by various processes. For example, high winds can blow fine soil and dust particles into the air, as can cars driving on roadways covered in small amounts of dust and dirt. Because the Denver area has a relatively dry climate and heavy traffic, dusts and surface soils can become airborne more easily in the VBI70 study area than in other parts of the country. These airborne contaminants can enter homes through open doors, open windows, and air intake vents. Unfortunately, ATSDR cannot evaluate the amount of contaminants in the outdoor or indoor air in the VBI70 study area, because no air monitoring data are available for this part of Denver.

In cases where homes exist atop contaminated soils, the contaminants can slowly accumulate in the air in the crawlspace beneath a house, and they can even enter homes through air intake vents, if any are located in the crawlspaces. In these cases, people inside their homes can be exposed to small amounts of contaminated dusts that come from their crawlspaces. In general, this type of exposure occurs to the greatest extent for contaminants that readily evaporate (such as gasoline), and occurs to a much lesser extent for those that do not readily evaporate (such as arsenic and lead, the main contaminants of concern for this site). Because no sampling studies have measured

levels of contamination in either crawlspace air or indoor air, ATSDR cannot determine whether this type of exposure is actually occurring in the VBI70 study area.

As noted above, no agency has collected indoor or outdoor air samples at the VBI70 study area. After EPA finishes investigating levels of contamination in soils, it will decide a follow-up investigation of air pollution in the study area is necessary. ATSDR will review data generated by such studies, if they are conducted.

Patterns of arsenic and lead contamination in the VBI70 study area

As discussed previously, ATSDR has found that soils contaminated with arsenic and lead present the greatest public health hazard at the VBI70 site. Focusing on the contaminated soils, ATSDR has evaluated how levels of lead and arsenic vary from one location to the next in the study area. This evaluation was necessary to determine whether the previous EPA soil sampling studies were sufficient and whether the studies should be expanded to consider soil contamination in other nearby areas. The following discussion reviews ATSDR's findings about levels of soil contamination throughout the VBI70 study area.

Lead distribution in the study area

The phase I and II sampling data, which includes results for roughly 1,500 properties, provides an excellent account of how levels of lead in surface soils vary throughout the VBI70 study area. As an example, Figure 12 in Appendix I illustrates the phase I and II sampling results by showing the locations with the highest lead concentrations as dark circles and the locations with the lowest lead concentrations as light circles. From this figure, a trend is readily apparent: The higher levels of lead in soils (or the darker circles) occur more frequently in the Elyria and Cole neighborhoods and the lower levels of lead in soils (or the lighter circles) occur more frequently in the Swansea and Clayton neighborhoods. In other words, the levels of lead in surface soils appear to decrease as one travels east in the VBI70 study area.

As further proof of this apparent trend, Figure 13 in Appendix I presents a similar account of the Phase I and II sampling results, but using different concentration ranges to display the data. As Figure 13 shows, the same data trend is apparent—higher levels of lead in the western portion of the study area than those in the eastern portion. Therefore, the somewhat arbitrary choice of concentration ranges in the figures appears to have no bearing on the data trend.

When reviewing the soil sampling results, ATSDR identified other notable data trends that deserve mention:

- The five highest soil concentrations of lead observed in the VBI70 study area during the phase I and II sampling occurred at three properties located within 1,000 feet of the former Omaha-Grant smelter. Four of the five highest levels came from samples taken below the surface (see Appendix I, Figure 15). This trend indicates that significant lead contamination in subsurface soils might occur near the former smelter.

- Surface soil sampling data from the Globeville community show a distinctive north-south trend in soil lead concentrations, in addition to the east-west trend discussed above. As Figure 16 in Appendix I shows, relatively lower lead levels were found in the northern portions of Globeville, while relatively higher lead levels were found in the southern areas.

- An interesting observation is that the variations in zinc concentrations in surface soils (see Figure 14 in Appendix I) throughout the study area is quite similar to the variations in lead concentrations (see Figures 12 and 13 in Appendix I).

- The maps show that the industrial area near the center of the VBI70 study area have not been extensively sampled. Therefore, levels of contamination in this area remain unknown.

In review, the trends depicted in Figures 12, 13, and 16 indicate that the current soil sampling data have extended to the north and the east to regions of notably lower lead concentrations. As a result, ATSDR can be reasonably confident that unusually high levels of residential soil lead contamination do not occur in areas further north or east than the current boundaries of the VBI70 study area. However, the available sampling data provide no evidence that significant soil contamination does not exist south and west of the VBI70 study area. In other words, significant lead contamination might exist south of Martin Luther King Boulevard/Blake Street and west of Fox Street/Burlington Northern Railroad, though these soils have not been tested by EPA's sampling efforts.

Lead distribution at several properties in the study area

Because of EPA's intensive sampling effort at eight properties in the study area, it is possible to evaluate lead distribution patterns at those properties and in some of the adjoining yards that EPA also sampled. The properties with high levels of lead generally show consistent elevated lead levels throughout the yards with some possible migration of lead onto adjoining properties. Other factors that might affect the distribution of lead levels at property lines include past construction and landscaping activities, for instance. The map in Appendix I, Figure 17, shows the distribution patterns for one of the properties with elevated lead levels in soil.

Arsenic distribution in the study area

ATSDR also evaluated how soil concentrations of arsenic vary from location to location in the VBI70 study area. Unlike the findings for lead, no obvious patterns in arsenic concentration were apparent (see Figure 18 in Appendix I). As Figures 19 and 20 in Appendix I show, more elevated soil concentrations of arsenic (greater than 300 ppm) were observed in the Swansea neighborhood than in the Clayton neighborhood; however, more soil samples were collected in Swansea when compared to Clayton. When correcting for the number of samples that were collected, ATSDR found no underlying trend to explain how soil concentrations of arsenic vary throughout the VBI70 study area.

Perhaps more important is the fact that EPA's sampling detected relatively high levels of arsenic at residences very close to the boundary of the VBI70 study area. This trend gives ATSDR reason to believe that elevated arsenic concentrations might occur in areas beyond the current VBI70 study area. Figure 23 in Appendix J shows the population density for the neighborhoods surrounding the VBI70 study area. Based on this map, areas with unknown, but possibly significant, arsenic contamination in soils include:

- Residential neighborhoods south and west of the study area, that is, south of Martin Luther King Boulevard/Blake Street and west of Fox Street/Burlington Northern Railroad
- Residential neighborhoods east and southeast of Clayton
- The industrial area in the central portion of the VBI70 study area

Arsenic at several properties in the study area

Because of EPA's intensive sampling effort at eight properties, it is possible to evaluate the distribution of arsenic levels in soil at those properties. Like the lead distribution, arsenic distribution in contaminated properties is generally consistent throughout those properties with one exception. That exception will be discussed later in the report.

EPA collected intensive soil samples from adjoining properties for six of the eight intensively sampled properties. At five of those six properties, elevated arsenic levels in soil were found at the property line of the adjoining yard, although the arsenic levels in soil from the adjoining properties were lower than those from the original properties. The arsenic might have migrated into the adjoining property as part of surface water runoff or in some cases past landscaping or construction activity may have caused the movement. The information below is an example of the different arsenic levels—the average arsenic level at one of the eight intensively sampled properties compared to the average arsenic level in an adjoining property, based on intensive samples and phase I and II samples:

Original property based on intensive samples	Adjoining property based on intensive sample	Adjoining property based on Phase I and II samples[18]
2,364 ppm	518 ppm	74 ppm

Appendix K, Figures 24 and 25, are maps of two properties showing soil arsenic levels in adjoining properties. Again, although some adjoining properties may have become contaminated by highly contaminated properties, the arsenic levels in the adjoining properties are lower. This phenomenon is important when evaluating the possibility of harmful effects occurring in soil pica children and in prioritizing properties that should be sampled again.

[18] It should be noted, however, that the average arsenic level from phase I and II may not be an accurate measure of arsenic levels throughout the property.

While properties that are highly contaminated with arsenic generally have high arsenic levels throughout their yards, some yards have patches of high arsenic contamination (see Appendix K, Figure 26). This pattern of patchy arsenic contamination becomes important when children's exposure to arsenic in soil is evaluated in relation to where children might play in yards.

The public health significance from exposure to contaminants

In evaluating the public health significance from exposure to contaminants at the VBI70 site, ATSDR evaluates how and when people get exposed to contaminants of concern identified for a site. This evaluation identifies where chemicals are in the environment, how they move in the environment, how people come into contact with chemicals in their environment, and who is likely to get exposed from that contact. Each way that people get exposed is called a pathway and people quite often are exposed to chemicals from different pathways. For the VBI70 site, ATSDR evaluated or considered the following:

- exposure to contaminants of concern by different pathways,
- total exposure to contaminants of concern by combining the pathways, and
- sensitive groups.

This part of the health assessment will give ATSDR's opinion about whether or not people could have elevated levels of exposure to contaminants and whether or not those people might experience harmful effects from that exposure. For the VBI70 site, the two contaminants of concern are arsenic and lead.

Human studies about the health effects of arsenic

Numerous human studies exist where people were exposed to arsenic through drinking contaminated water. A few of those studies will be described here. For instance, 40,000 people in Taiwan were exposed to arsenic for up to 45 years from drinking arsenic-contaminated well water. Fourteen thousand members of the group were children under 10 years old. Harmful effects from drinking arsenic-contaminated water were seldom seen in these children but were seen in adults who drank contaminated water for decades. In West Bengal, India, about 1,000 children were exposed to arsenic in drinking water. The West Bengal study was able to estimate the level of arsenic exposure in children that caused harmful effects as well as the level of arsenic exposure that was not likely to cause harmful effects. The harmful effects seen in children were hyperkeratosis and hyperpigmentation of the skin.[19]

[19] Arsenic-induced hyperkeratosis is a skin condition found most often on the feet and palms. Many small depressions occur in the skin with small, hard, outgrowths of skin in the center of each depression. Hyperpigmentation of the skin occurs as brown areas on the skin around the eyelids, temples, neck, nipples, and groin. In severe cases, pigmentation may cover the chest, back, and stomach. It sometimes appears as mottling on the skin and has been described as looking like raindrops. If mottling occurs, it is more frequent on the chest, back, and stomach.

In Chile, another group of people including children was exposed to arsenic through drinking water. In addition to hyperkeratosis and hyperpigmentation, some children showed patches of skin with less pigmentation accompanied by scaling of the skin. For these skin effects to occur, exposure to arsenic in drinking water had to take place for many years. ATSDR's evaluation of the possibility of arsenic causing harmful effects is based on these and other human studies (ATSDR 1998).

Children with soil pica behavior and the possibility of non-cancerous health effects from arsenic contamination in the VBI70 study area

Children who live on or visit arsenic-contaminated yards could be exposed to arsenic in soil and dust through hand-to-mouth activity.[20] From hand-to-mouth activity, most children accidentally swallow about 25 to 50 milligrams of soil and dust each day that cling to their hands and fingers.[21] Some children, however, accidentally swallow up to 200 milligrams of soil and dust each day from hand-to-mouth activity.[22] In addition to accidental ingestion, some preschool children purposely eat soil. This behavior is often referred to as pica behavior, which is the ingestion of non-food items. For the purposes of this report, ATSDR will refer to this type of activity as soil pica behavior and to these children as soil pica children. Soil pica children typically eat about 5,000 milligrams of soil at a time.[23] During this time, they could likely eat soil anywhere from a day or two days or could continue eating soil periodically for several days a week for several weeks.

Knowing the level of arsenic in soil and knowing that children swallow up to 5,000 to 10,000 milligrams of soil or dust allows ATSDR to estimate how much arsenic children might be exposed to each day. Since the Denver area has a dry environment, particularly in the summer, some yards have little grass cover or have areas in the yard with bare soil. These sparsely covered or bare areas could allow children with soil pica behavior easy access to arsenic-contaminated dirt. Soil pica behavior is more likely to be a problem during the warm weather months when children are more likely to play outside.

Based on chemical tests by EPA, arsenic at the VBI70 site is bound to very small dirt particles (EPA undated). Being bound to smaller particles might allow for greater contact with the lining of intestinal tract (that is, the gut) and may increase absorption into the body. However, because arsenic could be bound tightly to soil and dust in some instances, some arsenic may not be absorbed through the intestinal tract into the body. Therefore, in these cases, actual

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[20] Hand to mouth activity occurs when children put their hands in their mouth or when children suck their fingers.

[21] Twenty-five to 50 milligrams of soil and dust is about 1/16 of a teaspoon.

[22] Two hundred milligrams of soil and dust is about 1/8 of a teaspoon.

[23] Five thousand milligrams is 1 tablespoon.

exposure could be less than expected. Other things that might affect the amount of arsenic that is absorbed into the body are the contents of the intestinal tract from food and the time from the last meal. These competing factors cause some uncertainty in estimating how much arsenic actually gets into the body.

For children with soil pica behavior, the amount of exposure depends upon the level of arsenic in the area of the yard where they grab a handful of soil. Since it is possible that soil pica children could play in areas of a yard that have the highest level of contamination, ATSDR uses the highest level of arsenic found in the yard when estimating exposure for soil pica children. Currently, the highest level of arsenic in soil that is present at properties that have been tested in the study area is 4,798 ppm. When we look at the information about soil pica behavior, about 30 properties exist in the study area that currently have at least one and sometimes many soil samples that are highly elevated.[24] At 18 properties where the EPA has cleaned up contaminated soil, the same risk exists for soil pica children. The highest level of arsenic in those 18 properties was 16,176 ppm.[25] It was very common at these highly contaminated properties to find very high levels of arsenic throughout the yard, often in the thousands of ppm arsenic.

No health guideline exists for evaluating short-term exposure to arsenic.[26] Therefore, ATSDR uses direct comparison to human studies. For children with soil pica behavior at these highly contaminated properties, the amount of exposure to arsenic could be similar to exposures in human studies where serious health effects were observed. The most likely signs and symptoms if a soil pica child ate highly contaminated soil could be nausea, stomach cramps, vomiting, and diarrhea.[27] These health effects most likely result from a direct effect of arsenic on the lining of the gut. For children at contaminated properties where soil pica behavior occurs several times a week, it could be that other signs and symptoms might occur. Those signs and symptoms include:

- swelling of the skin around the eyes,
- eye irritation,
- redness around the eyes,
- headache,

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[24] This information is based upon sample results from the Phase I and II, confirmation, and intensive sampling rounds conducted by EPA in 1999. These numbers are likely to go up when Phase III soil data are available.

[25] At some of the other 18 properties, the highest level found at different properties was 11,785 ppm; 4,798 ppm; 4514 ppm; 3,046 ppm; 2,976 ppm, etc.

[26] Short-term exposure refers to exposures lasting from 1 day to several months or several years.

[27] Diarrhea is frequent, loose bowel movements.

- laryngitis,[28]
- sore throat,
- rapid heart beat,
- severe nose bleeds,
- liver damage, and
- lowered white cells in the blood (Armstrong 1984, ATSDR 1998, Franzblau 1989, Mizuta 1956).

Since many of these signs and symptoms are common in children from other causes, it is not possible to use the previous list to determine if a soil pica child is experiencing arsenic-induced health effects.

Sufficient information about arsenic in soil is available for the 55 properties that were part of the confirmation sampling round and for the 8 properties that were part of the intensive sampling rounds totaling 63 properties. Therefore, it is possible to evaluate the public health significance of arsenic contamination in those 63 properties. Most of the 1,500 properties sampled in phase I and II, however, do not have sufficient information about arsenic in soil to determine whether or not arsenic levels are safe or harmful for children with soil pica behavior.

Children with typical soil intake and the possibility of non-cancerous health effects from arsenic contamination in the VBI70 study area

Using simple mathematics, ATSDR is able to estimate the range of arsenic exposure for children with typical soil intakes of 25 to 200 milligrams who live in the VBI70 study area. This information is then compared to the arsenic exposure levels identified in human studies. Based on ATSDR's estimate of the arsenic exposure that might occur at the more highly contaminated properties, children with typical soil intake levels are not likely to experience non-cancerous harmful effects from arsenic in soil.

Adults and the possibility of non-cancerous health effects from arsenic contamination in the VBI70 study area

While ATSDR and EPA do not have a health guideline for short-term exposure to arsenic, both ATSDR and EPA have the same health guideline for long-term exposure to arsenic.[29] ATSDR's health guideline is called a Minimal Risk Level (MRL), and EPA's health guideline is called a Reference Dose (RfD). An MRL or RfD is an exposure level below which you would not expect to observe harmful health effects. It is important to note that the MRL and the RfD apply to non-cancerous effects and cannot be used to determine whether or not people could develop cancer (ATSDR 1998).

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[28] Laryngitis is a redness around the larynx and often leads to a hoarse voice.

[29] Long-term exposure refers to exposures for many years.

Since we can also estimate how much soil adults accidentally swallow each day, it is possible to estimate the exposure to arsenic for adults who live in the study area. At the two properties in the study area with the highest average arsenic levels, the amount of arsenic exposure to adults just barely exceeds ATSDR's MRL and EPA's RfD.[30] The estimated amount of arsenic exposure in adults at these two properties is well below the level where no harmful health effects were observed in the Taiwan study. The Taiwan study is thought to be one of the best studies available for evaluating the human health effects from long-term exposure to arsenic. Therefore, it is unlikely that the adults at these two properties in the VBI70 study area will experience non-cancerous harmful effects from arsenic in soil (ATSDR 1998). This same conclusion applies to other properties with lower levels of arsenic.

For long-term exposure in adults and children with typical soil intake, ATSDR is only able to evaluate arsenic exposure at 63 properties at this time using the data that are currently available. The EPA should have environmental data available in January 2,000 to evaluate approximately 3,000 properties that were not previously sampled. The EPA has also reported that they plan to resample some of the 1,500 properties previously sampled as part of the phase I and II sampling rounds.

People who live in the VBI70 study area and possible cancerous effects

There is convincing evidence from a large number of human studies and case reports that arsenic causes cancer. These human studies involve people who were exposed by drinking aresenic-contaminated drinking water, from taking arsenical medications, and from breathing arsenic in the workplace. Arsenic in drinking water and medications has been shown to cause skin cancer. The types of skin cancer commonly seen are squamous cell carcinomas and basal cell carcinomas.[31] Squamous cell carcinoma commonly occurs at the same location on the skin where hyperkeratosis is found whereas basal cell carcinomas typically arise from unaffected areas of the skin. While skin cancer is the main type of cancer caused from arsenic exposure, Arsenic may also cause other types of cancer, such as, cancer of the lungs, bladder, breast, larynx, kidneys, and liver. Both the Department of Health and Human Services, which ATSDR is a part of, and the EPA have classified arsenic as a known cancer-causing agent in humans. Arsenic has been shown to cause cancer in people exposed for 10 to 20 years as well as exposures lasting a lifetime (ATSDR 1998).

Adults and children who live on the most highly contaminated yards have estimated exposure levels to arsenic that are similar to those exposure levels in human studies that have been

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[30] The soil at these two properties was cleaned up by EPA in 1998.

[31] Squamous cell carcinoma of the skin is a locally invasive skin cancer that arises from the squamous epithelium layer in the skin and that has the ability to travel to other parts of the body.

Basal cell carcinoma of the skin is locally invasive skin cancer that arises from basal cells in skin. It rarely travels to other parts of the body.

shown to cause cancer. The amount of arsenic exposure varies over a person's lifetime. Because of the potential to ingest soil, the potential for exposure to arsenic in soil is highest in preschool and elementary-age children. Because teenagers and adults have less soil ingestion, their exposure to arsenic in soil would be less.

Another way to evaluate the cancer-causing potential from arsenic in soil is to use mathematical estimates. The EPA suggests a mathematical method for estimating the increased risk of cancer that people might theoretically have based on exposure, such as arsenic. For the VBI70 study area, the risk is estimated by taking the average arsenic level in someone's yard and to estimate the amount of arsenic exposure throughout someone's life. This mathematical estimate is used to estimate cancer risk when arsenic exposure levels are below the exposure levels shown in human studies to cause cancer. There is some uncertainty in this mathematical estimate for several reasons.

- The mathematical model assumes that the risk is linear, that is, as the exposure level decreases, the risk decreases at the same proportional rate.[32]
- The human body may be able to metabolize arsenic when exposures are low so that it is not harmful to people.
- The Taiwan study may have made mistakes in estimating the amount of exposure to arsenic.
- The nutrition of people in the Taiwan study may affect how arsenic is handled by the body.
- People in the Taiwan study may have been exposed to arsenic in other ways besides just drinking water (ATSDR 1998).

In addition to these points, some scientists believe that exposure to small amount of arsenic are safe if the amount of exposure is below a threshold for cancer. That is to say that small amounts of arsenic might not cause cancer (Stöhrer 1991; Abernathy et. al. 1996). This topic is still being debated among scientists.

In deciding whether or not a theoretical risk of cancer exists for people who live on arsenic-contaminated yards at the VBI70 study area, ATSDR assumes that during 30 to 70 years of potential exposure, people will accidentally swallow small amounts of soil throughout their lives. Based on those assumptions, there is a significant theoretical increase in cancer risk at many of the 63 properties that were part of the confirmation sampling round and the intensive sampling round. It is not possible at this time to estimate the theoretical increase in cancer risk for the remaining almost 1,500 properties in the VBI70 study area that were part of phase I and II sampling rounds. EPA's phase III soil sampling round, which will be available in 2000, will produce sufficient information to estimate the potential cancer risk for residents who live on the properties sampled.

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[32] It is not possible to know whether or not the risk is linear because no data exist to prove or disprove this assumption about the linear risk.

Possible health effects in children and adults from exposure to lead in the VBI70 study area

Several of the 63 properties with sufficient soil data had elevated levels of lead in surface soil. The four properties with the highest average lead levels were cleaned up by the EPA in 1998 along with several other properties with elevated lead levels in soil.[33]

Exposure to lead in soil occurs in the same manner as described previously for exposure to arsenic in soil. Preschool children have the greatest amount of exposure because of their frequent contact with soil and because of their hand-to-mouth activity. Exposure from contact with lead-contaminated soil at the more highly contaminated properties that were cleaned up in 1998 might have increased blood lead levels in some preschool children in the past and might have caused harmful effects involving the brain and nervous system. Blood lead levels as low as 10 μg/dL have been shown to cause the following effects: [34]

- neurobehavioral effects
  decreased intelligence
  developmental delay
- growth
  decreased stature
- endocrine effects
  altered vitamin D metabolism
- blood effects
  changes in blood enzyme levels
- auditory effects
  decreased hearing (ATSDR 1999, CDC February 1991).

These effect might be possible in some preschool children who lived at properties with high lead levels in soil.

In addition to lead exposure from contaminated soil, children can also be exposed to other sources of lead. They include lead-based paint in houses built before 1978, dietary lead, lead-containing material used in occupations and hobbies, lead-containing ceramic ware and traditional remedies to name a few (CDC 1977).

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[33] The average level of surface soil lead in those four properties ranged from about 1,000 ppm to 1,700 ppm.

[34] μg/dL means micrograms lead per 100 milliliters of blood.

Lead-based paint in homes is a significant source of lead exposure for U.S. children. About 80% of homes built in the U.S. before 1978 still contain some lead-based paint. The older the house, the more likely it is to contain lead-based paint and to have a higher concentration of lead in paint. Housing built before 1950 poses the greatest risk of exposure to children (CDC 1977).

Based on confirmation samples, several properties currently have average lead levels in soil between 400 and 1,000 ppm. In addition, the intensive sampling round, which sampled some properties up to 15 feet from the property line, identified several properties with high levels of lead in soil. Because of the limited sampling of these (adjoining) properties in the intensive round, it is not possible to determine whether or not lead in soil at those properties could harm children's health.

As for the 1,500 properties sampled in phase I and II, most properties do not have sufficient information about lead in soil to determine whether or not lead levels are safe or harmful for children. EPA's phase III soil data should provide information on 3,000 properties that will allow ATSDR to evaluate the possibility of harmful effects from exposure to lead in soil.

Properties that refuse to allow clean up

Three properties at the VBI70 study area have refused to allow EPA to clean up arsenic-contaminated soil. The level of arsenic in soil at these properties could cause harmful effects in soil pica children who live at the properties or who visit the properties and play in the yard. In addition, preschool and elementary age children who live at these properties could be exposed to arsenic at levels that have been shown to cause cancer in human.

Questions and concerns from the community

ATSDR staff members have met with community representatives many times and have had one availability session for residents.[35] During those meetings, health and environmental questions were raised. ATSDR's answer, which is in italics, follows the question. Some questions were referred to the appropriate federal, state, or local agency.

3. How can residents reduce exposure to contaminants in their yard?

The VBI70 health team developed a handout that shows residents some simple steps they can take to reduce or stop exposure to contaminants in soil (see Appendix L). Examples include:

- *washing hands frequently,*
- *removing shoes before entering homes,*
- *washing fruits and vegetables,*

[35] An availability session is a meeting that is held in a community so that residents can come and talk one-on-one or in small groups with ATSDR employees.

- *washing dogs,*
- *damp mopping floors, and*
- *damp dusting counters and furniture.*

2. What is the meaning of environmental and health terms that might be used during team meeting?

   The community representatives asked that government officials be aware that they might not understand all the technical terms and government jargon that is frequently used when talking about the VBI70 site. ATSDR staff members and other government officials worked with community members during our meetings to make sure that the use of technical terms was limited. When technical terms had to be used, they were defined for the members of the team. ATSDR staff members had several meetings with community representatives to help them understand the technical terms and the process used to make public health decisions.

3. Community representatives would like to have technical assistance in developing and presenting messages to the community. Community representatives also want to set up the meetings with the community.

   Agency members of the VBI70 health team agreed to help community representatives with technical issues and agreed that community representatives should be an integral part of setting up meetings with the community. Agency members also agreed to help community representatives with developing and presenting messages to the community. For example, when ATSDR released its fact sheet on gardening in the VBI70 study area, ATSDR staff members worked with community members to develop the fact sheet and to set up meetings in the community for the residents to answer questions about gardening. ATSDR also worked with community representatives as they wrote and used parts of the fact sheet in the newsletter for Swansea and Elyria.

4. Community representatives reported that there is an old landfill in the Clayton neighborhood and suggested that someone provide more information in writing to the community about the landfill. Some issues about this landfill are (A) where is it, (B) when was it active © is there environmental data on the landfill, (D) can it be monitored. One community representative said that Adams Street in the Clayton neighborhood was built on top of the landfill. It is important that the information be in writing.

   Ms. Barbara O'Grady, the site lead for CDPHE, said that CDPHE will respond to this issue. Ms. O'Grady said that Mr. Glenn Malloy (303-692-3445) or Mr. Peter Laux (303-692-3455) with CDPHE's Solid Waste Unit might have answers about the landfill. Also, Ms. Celia VanDerLoop (City and County of Denver) said that she may also have information about landfills in the neighborhoods.

5. What industrial processes are currently going on at the ASARCO facility in Globeville. Community representatives would like to have an explanation of the chemical processes involved, particularly as it relates to emissions. There is a question about what is

meant by a process for high purity metals.

During the investigation, ASARCO officials conducted a tour of the ASARCO Globe facility to allow government officials and community representatives to become familiar with the facility. In addition, ATSDR learned from ASARCO representatives that currently the facility produces bismuth products,[36] litharge,[37] highly purified lead, and tellurium.[38] Small amounts of highly purified "specialty metals" are also produced. Specialty metals produced during the last year include cadmium telluride, cadmium sulfide, lead telluride, zinc telluride, and high purity copper cylinders.

6. Community representatives asked several questions about why non-cancerous health effects were increased in the community. Examples of non-cancerous effects include asthma, respiratory (lung) diseases, skin rashes, thyroid disease, kidney disease, stomach problems, children in remedial/special education classes, and retarded children? Community representatives also expressed concern about there being a two-fold increase of cancer of the larynx and kidney in the community and an increase in leukemia?

ATSDR does not know whether or not the cancerous and non-cancerous effects mentioned are greater than expected for this part of Denver. Decisions about whether or not to determine cancer and non-cancerous disease rates for the VBI70 study area will be made at a later date.

7. The community wants to be educated so they will know what questions to ask their doctors based on the health effects that might occur from exposure to contaminants in soil. Community representatives would also like the VBI70 health team to educate doctors so they know what to look for and would be willing to test for certain effects.

The CDPHE has a cooperative agreement with ATSDR to conduct health education in the community. The agencies are working with community representatives on these issues. For instance, a letter to physicians has been drafted to inform them of the VBI70 site. As the agencies continue to work together with community representatives, other activities may also be started.

8. How was 70 parts cadmium per million parts soil (70 ppm cadmium) established as a clean-up level for Globeville?

Since CDPHE developed the 70 ppm cadmium clean-up number for the Globeville ASARCO site, ATSDR has referred this question to CDPHE staff members.

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[36] Bismuth is metal like lead and arsenic and is used in making pharmaceutical products (for example, Pepto Bismol). It is also used in industrial processes.

[37] Litharge is an oxide of lead made by heating metallic lead.

[38] Tellurium is a nonmetallic element similar to sulfur. It has a number of industrial uses, for example, as part of stainless steel and iron castings as well as a coloring agent in glass and ceramics.

In a letter dated March 24, 1999, ATSDR informed EPA of several questions and concerns that community representatives raised during meetings with ATSDR staff members. The questions and concerns are listed below:

- A better understanding is needed of the sampling methods EPA used at the VBI70 site. More specifically, what is the difference between a composite versus an average and how will the difference between the two be used in EPA's risk assessment?
- Why did EPA not sample for cadmium and zinc?
- Why were certain houses deleted from the list of houses for emergency cleanup?
- A better understanding is needed of EPA's risk assessment process.
- What is the meaning of environmental and health terms that might be used during workgroup discussions?

ATSDR's letter to EPA can be found in Appendix M.

Health outcome data

ATSDR sometimes evaluates health outcome data during the health assessment process and includes the results as part of its public health assessment. At other times, health outcomes are evaluated after the report is written. In this report, ATSDR will evaluate medical tests performed by EPA and will describe medical tests that ATSDR plans to conduct.

Historical medical tests in the VBI70 study area conducted by EPA

During EPA's phase II investigation in 1998, EPA identified 21 residences that required immediate clean up because of high levels of soil arsenic (greater than 450 ppm arsenic) or high levels of soil lead (greater than 2,000 ppm lead). EPA collected biological samples from some of the residents of those properties and measured lead levels in blood and arsenic levels in urine and hair. Based on questionnaire information from 17 of the 21 properties, 69 people were identified who could participate in EPA's biological survey. Fifteen people from 6 residences volunteered to participate.

The number of participates in different age groups are given below.

preschool children	1
children/teenagers	5
adults	9

Knowing the distribution of ages is important in interpreting the meaningfulness of the results since preschool children are likely to have the highest amount of soil intake.

EPA reported that no arsenic was found in the urine of people tested.[39] EPA stated, however, that 5 of the urine samples had detection limits for arsenic above the desired detection limit of

[39] The detection limit for arsenic in urine was as low as 10 μg/dL for some sample.

50 micrograms per liter (μg/L), which limits the usefulness of these 5 samples. The five participants refused to provide additional samples. The results of the remaining urinary arsenic levels showed that those participants did not have excessive exposure to arsenic at the time the urine samples were collected. Caution is needed when drawing conclusions about the safety of arsenic in soil based on these urinary arsenic results. The reasons are as follows:

- participants came from only 6 properties,
- only 1 preschool child, the group most likely to be affected by soil arsenic levels, was tested,
- blood samples were collected in late fall or early winter when outdoor activities were likely to be reduced,
- blood samples were collected at one point in time,
- the extent of arsenic contamination in some yards was not known,[40] and
- 17 participants is too few a number to represent all the people in the study area.

As for hair arsenic levels, it is not unusual to find small amounts of arsenic in hair. One of the participants in EPA's survey had arsenic in the hair at 0.41 ppm, which is less than the common reference value of 1 ppm. A level of 0.41 ppm of arsenic in hair is not considered to be clinically significant. Two of the remaining 14 non-detectable levels were above the desired detection limit of 1 ppm. These two participants refused to provide another hair sample. Arsenic can be found in hair from two pathways. First, arsenic that is absorbed into the body can become part of newly made hair as the hair grows. Second, arsenic in dust and arsenic in human sweat can become bound to any part of the hair directly from the external environment. When measuring hair arsenic levels, it is not possible to know if arsenic in hair comes from the external environment or from being incorporated into the base of the hair through the hair's follicle. This problem with the different ways arsenic can get into hair makes it difficult to establish background levels of arsenic in hair and to interpret the meaning of hair arsenic levels.

As for blood lead levels in the participants, they ranged from 1 to 4 micrograms lead for each 100 milliliters of blood (or μ/dL) with a geometric average of 2.2 μg/dL.[41] The Centers for Disease Control and Prevention (CDC) in Atlanta has established 10 μ/dL as a guideline for deciding when actions should be taken to reduce blood lead levels. When levels are below 10 μ/dL, CDC recommends that no actions be taken. Based on a national survey from 1991 to 1994, the geometric mean for blood lead was found to be 2.8 μ/dL for people aged 1 to 74 years (CDC October 1991, ATSDR 1999).

[40] Because of confidentiality issues, EPA has shared only summary information about urinary and hair arsenic levels and blood lead levels. Having only summary information limits ATSDR's ability to perform a more thorough evaluation of these biological tests.

[41] Blood lead levels are typically reported as μ/dL. Human studies on the health effects of lead quite often focus on blood lead levels. Therefore, one can determine the possibility of harmful effects by knowing the blood lead levels and the age of the person. The geometric average is calculated when one wants to reduce the influence that unusually high or low values have on the average. The EPA did not provide an arithmetic average of blood lead levels.

The blood lead results for the 15 people who participated shows that at the time of the testing they did not have excessive exposure to lead. The blood lead results, however, cannot be used to draw conclusions about the safety of lead levels in soil at the VBI70 site.

Future medical tests in the VBI70 study area by EPA

ATSDR with input from EPA, CDPHE, the City and County of Denver, and community representatives plans to collect biological samples in the spring and summer 2000 from some of the residents of the VBI70 study area.[42] At the time of the writing of this report, ATSDR plans to test some preschool children and adults for urine arsenic levels who live at the more highly contaminated properties. The purpose of the investigation is to determine whether or not excess arsenic exposure is occurring among those residents. The results will be used to identify appropriate follow-up health activities for residents who live in the VBI70 study area.

ATSDR and EPA efforts for a consistent approach to evaluating short-term exposure to arsenic

During the investigation of soil arsenic levels at the VBI70 site, ATSDR raised concerns about arsenic exposure in children with soil pica behavior. Since EPA lacks guidelines for evaluating arsenic exposure in this situation, EPA proposed in October 1999 that the two agencies form a national group to evaluate the harmful effects of arsenic in people from short-term exposure. The focus of the evaluation concerned the harmful effects from short periods (for example, 1 day to several years) of arsenic exposure. The agencies have identified many scientific papers that form the basis for some of the decisions being made in this public health assessment. The purpose of this effort was to ensure a consistent approach between ATSDR and EPA at the VBI70 site and to ensure a nationally consistent approach by EPA at other sites in the US.

Health education and promotion at the VBI70 site

As part of ATSDR's investigations at hazardous waste sites, activities such as health education and community involvement are often conducted prior to the release of the public health assessment or other reports.

ATSDR currently has a cooperative agreement with CDPHE to conduct health education activities at the site. The agencies, along with the health team members, have already conducted some health education activities related to VBI-70. The group is also working together to plan additional activities related to health care provider education and distributing information regarding the upcoming medical testing.

In April 1999, ATSDR along with the CDPHE evaluated the safety of gardening in the VBI-70 area. Based on this evaluation, the health team members developed two fact sheets describing safe gardening practices and outlining the results from the evaluation (see Appendices G and H). The documents were distributed in both English and Spanish to residents around the VBI-

[42] Testing is planned for the spring and summer because exposure to contaminants in soil is likely to be high in those months from increased outside activity by children and adults.

70 site and were printed in one of the community newsletters, which was sent to approximately 2200 residents. The group also held two public availability sessions at the Herrington Elementary School and the Swansea Community Center in April 1999. During these meetings, residents were able to ask questions regarding the safety of gardening in the area as well as receive gardening tips from a horticulturist from the University of Colorado. ATSDR also prepared and released an information sheet to residents that outlined some general steps that they could take to protect their health and prevent exposure to contaminants in soil (see Appendix M). Other activities such as contacting local health care providers to introduce them to the VBI70 site and developing educational materials for the upcoming medical testing are in the early stages of development.

ATSDR's child health initiative

To ensure that the health of the nation's children is protected, ATSDR implemented an initiative requiring that health assessments determine whether or not children are being exposed to site-related hazardous waste and whether or not the health of children might be affected.

When soil is a pathway of concern, as it is at the VBI70 site, children will have greater exposure to contaminants in soil than adults. This is the case for arsenic and lead in soil at the VBI70 site. Children's exposure to arsenic and lead in soil was a major focus of ATSDR's investigation at the VBI70 site and significantly affected ATSDR's efforts. More specifically, children with soil pica behavior became a major factor in the public health decisions that ATSDR made.

Conclusions

Conclusions about health

In 1998, EPA collected soil samples from properties in the VBI70 study area as part of phase I and II sampling rounds of 1,500 properties, a confirmation sampling round of 55 properties, and an intensive sampling round focused on 8 properties. High arsenic levels in soil can be found at certain properties in the study area. Possible exposure to arsenic in soil occurred and continues to occur at certain properties that is a concern for preschool children with soil pica behavior. In addition to these properties, past exposure to high arsenic levels may have occurred at 18 properties before EPA stopped exposure in 1998 by removing contaminated soil. Possible exposure to arsenic at the properties mentioned might cause serious health effects in preschool children with soil pica behavior. The most likely signs and symptoms in these soil pica children from eating soil with high amounts of arsenic could be nausea, stomach cramps, vomiting, and diarrhea. For soil pica children at these contaminated properties where this behavior occurs several times a week, other possible signs and symptoms might include:

- swelling of the skin around the eyes,
- eye irritation,
- redness around the eyes,
- headache, laryngitis,
- sore throat,

- rapid heart beat,
- severe nose bleeds,
- liver damage, and
- lowered white blood cells.

For these properties, adults and children with typical soil intake levels who live on or visit those properties are not likely to experience non-cancerous harmful effects from arsenic in soil.

This possiblity of harmful effects in soil pica chidlren applies only to a limited number of where exposure occurred in the past and is known to be currently happening and to the 18 properties that were cleaned up by EPA. Insufficient information exists on most of the other properties in the study area to determine their public health significance. EPA, however, is currently evaluating 3,000 properties so additional information about arsenic and lead contamination will be available soon. Personal communication from EPA's project manager for the VBI70 site indicates that preliminary soil data on the 3,000 properties shows that many properties are not contaminated with arsenic and lead.

ATSDR is also concerned about many of the 63 properties that were part of the confirmation sampling round and the intensive sampling round because of high levels of arsenic and the possibility of cancer. Adults and children can be exposed to arsenic in soil from hand-to-mouth activity. Adults and children who live on the most highly contaminated yards have estimated exposure levels to arsenic that are similar to exposure levels in human studies that have been shown to cause cancer in people. It is not possible at this time to determine the cancer risk for most of the 1,500 properties in the VBI70 study that were part of phase I and II sampling rounds. EPA's phase III soil sampling round, which will be available in 2000, will provide sufficient information to estimate the potential cancer risk for residents who live on the properties sampled.

ATSRD is also concerned about preschool children who lived in certain properties with high levels of lead. Several of the 63 properties with sufficient soil data have elevated levels of lead in surface soil. The four properties with the highest average lead levels were cleaned up by the EPA in 1998 along with several other properties with elevated lead levels in soil. Exposure from contact with lead-contaminated soil at the more highly lead-contaminated properties before they were cleaned up in 1998 might have increased blood lead levels in some preschool children in the past and might have caused harmful effects involving the brain and nervous system. Possible effects include a decreased intelligence, developmental delays, decreased stature, altered vitamin D metabolism, changes in blood enzyme levels, and decreased hearing.

Several data gaps exist in determining the extent of soil lead levels in the study area. The intensive sampling round, which sampled some properties up to 15 feet from the property line, identified several properties with high levels of lead in soil. Because of the limited sampling of these (adjoining) properties in the intensive round, it is not possible to determine whether or not lead in soil at those properties could harm children's health. As for the 1,500 properties sampled in phase I and II, most properties do not have sufficient information about lead in soil to determine whether or not lead levels are safe or harmful for children. EPA's phase III data

should provide information on 3,000 properties that will allow ATSDR to evaluate the possibility of harmful effects from exposure to lead in soil.

Three properties have refused to allow EPA to clean up arsenic-contaminated soil These properties are a health hazard to the current residents at those properties and to the families that might occupy those properties in the future.

Conclusions about environmental samples

One of the adjoining properties that was sampled during the intensive sampling round and that was found to have arsenic-contaminated soil was not sampled during Phase I and II or during the confirmation sampling round. ATSDR is uncertain whether or not this property will be sampled during Phase III.

The results of Phase I and II sampling rounds for arsenic and lead levels in soil is very limited in making public health decisions. Because only two surface soil samples were collected, the results cannot be used to estimate the average level for arsenic and lead in soil. Therefore, Phase I and II results cannot be used to estimate long-term human exposure. Only the 55 properties where confirmation samples were collected and the 8 properties that were the focus of the intensive sampling round have sufficient information about arsenic and lead levels in soil to evaluate the public health significance of long-term exposure to soil contaminants.

Five of highest lead levels in soil from the study area are found in three properties within 1,000 feet of the former Omaha-Grant smelter. This observation indicates that significant lead contamination might exist at and below the surface near the former smelter.

The distribution of lead in and around the VBI70 study area shows that lead contamination might exist south and west of the study area. In addition, significant soil lead contamination might exist in the central industrial area inside the study area. Since no pattern was obvious for arsenic contamination, properties outside the study area could have significant levels of arsenic in soil.

Sediment in the VBI70 study area have not been characterized. ATSDR is uncertain whether or not sediment samples from the South Platte River that were taken as part of the ASARCO Globe Plant investigation sufficiently characterize sediment in that portion of the South Platte River that flows through the VBI70 study area.

When phase III and other environmental data are available, ATSDR will evaluate its public health significance.

Conclusions about other health activities

As part of ATSDR's investigation of hazardous waste sites, activities such as health education and health promotion are often considered once the public health assessment is completed. Some initial activities concerning health education have been conducted. They include creating two fact sheets on gardening, holding an availability session for residents to answer their questions about gardening, and preliminary work on developing a plan for testing urinary

arsenic in some residents.

Recommendations

1. Because Phase I and II data cannot be used to completely characterize human exposure, ATSDR recommends that EPA collect soil samples from all the properties sampled in Phase I and II and measure for arsenic and lead.

2. ATSDR recommends that EPA collect surface soil samples from a specific properties on Milwaukee Street, Clayton Street, and Thompson Court that may currently have high levels of arsenic and measure for arsenic and lead. ATSDR will identify this property to EPA by letter.

3. ATSDR recommends that EPA collect surface soil samples from several properties that may currently have high levels of lead and measure for lead and arsenic. ATSDR will identify these properties to EPA.

4. ATSDR recommends that EPA collect surface and depth samples from the area around the former Omaha-Grant smelter. The area sampled should extend at least 1,500 feet from the former smelter.

5. ATSDR recommends that EPA collect surface soil samples south of the study area, that is, south of Martin Luther King Boulevard and Blake Street; west of the study area, that is, Fox Street; and east and southeast of the Clayton neighborhood.

6. ATSDR recommends that EPA collect surface and depth sediment samples from drainage ways in and around the VIB70 study area and from the South Platte River if that river was not adequately characterized for arsenic and lead as part of the ASARCO Globe Plant Site.

7. ATSDR recommends that EPA, CDPHE, and the City and County of Denver develop a notification system for properties where EPA is not allowed to clean up contaminated soil. The notification system should inform future occupants of those properties of existing arsenic or lead contamination in soil.

8. ATSDR recommends that an exposure investigation be conducted to determine if residents who live on properties with high levels of soil arsenic are being exposed.

9. The Division of Health Education and Promotion in ATSDR will evaluate the VBI70 site for possible health education and promotion activities. This process will include an evaluation of the health education activities that have been conducted to date and an assessment of the site for possible health education and promotion activities based on this evaluation.

Public Health Action Plan

The purpose of the public health action plan (PHAP) is to ensure that this public health assessment goes beyond presenting ATSDR's conclusions and recommendations about public health issues at the VBI70 site. The PHAP describes actions during the health assessment process that were taken to protect public health as well as actions that are planned. The PHAP at the VBI70 site involves two areas: health education activities and medical testing.

Health education activities

During the public health assessment process that took place in late 1998 and 1999, ATSDR staff members met with community representatives about once every month. During those meetings, ATSDR staff members and community representatives as well as other members of the health team developed two gardening fact sheets. The gardening facts sheets provided information to residents about the safety of gardening of the VBI70 study area. The gardening fact sheets were either mailed to residents or handed out at availability sessions that the health team had for residents in April 1999. As part of the availability session, health team members met with residents one-on-one to answer their questions about gardening and the site. In addition, a flyer was given to residents showing them things they could do in their house and yard to reduce exposure to arsenic and lead in soil. In addition, a horticulturist from the University of Colorado was on hand to answer questions about gardening in Denver.

CDPHE and ATSDR are also currently working on other health education activities. For instance, CDPHE is writing a letter to local health care providers to inform them of the public health issues at the VBI70 site. The health agencies are also looking at whether or not to develop other health education activities for site.

Medical testing

During the public health assessment process, ATSDR decided to measure urinary arsenic levels in children and adults who live at properties with high arsenic contamination in soil. This exposure investigation will take place in the spring or summer 2000 and will be used to decide future public health actions for the site.

Other activities

ATSDR has been working with EPA, CDPHE, and the City and County of Denver on public health issues at the VBI70 site. As part of that joint effort, ATSDR has made recommendations to the agencies to protect public health and will continue to work with these agencies as they decide what actions should be taken to protect public health.

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Appendix A

Figures 1 and 2

Study area boundary and NPL site boundary

Appendix B

Figure 3

Timeline of ATSDR's public health assessment activities at the VBI70 site

Appendix C

Figures 4 and 5

Information about the people who live within the study area boundary and who live within the VBI70 NPL site boundary

Appendix D

Figures 6, 7, 8, 9, and 10
1990 Demographics for the VBI70 Study Area

Tables D-1, D-2, and D
1998 and 2003 Estimated Demographics for the VBI70 Study Area

1998 and 2003 Estimated Demographic for the VBI70 Study Area

The demographic data presented in the main body of the report are taken from the 1990 census. Though more current census data are not available, ATSDR obtained and reviewed estimates of neighborhood-level demographic data for the years 1998 and 2003 to provide insights into the current demographics of the VBI70 study area. These estimates were prepared by Claritas, Inc.—a company that specializes in projecting future demographic data for specific geographic areas. Not only do the data provided by Claritas estimate total population in the VBI70 study area, but they also characterize additional information relevant to this public health assessment, such as the age of houses and the average time people live in their homes.

The following list reviews important data trends derived from the demographic data provided by Claritas. Data summary tables are also included in this appendix to highlight notable demographic trends.

- *Population trends and socioeconomic status by neighborhood.* Figure 5 gives an overview of the demographics of the VBI70 NPL site. As the figure shows, roughly 5,800 people reside within the boundary of the Superfund site. Not shown in the figure is the fact that nearly 10,000 additional people reside within the boundary of the VBI70 study area. Across the study area, about 60% of the residents are of Hispanic origin, roughly 30% are African-Americans, and the remaining residents are of different races.

  Table D-1 and Figures 6–10 indicate the breakdown of the population by race for the five neighborhoods that make up the VBI70 study area. The data in the table and figures show that the Clayton and Cole neighborhoods have a considerably higher population than the other three neighborhoods. In all five neighborhoods, however, African-American and Hispanic residents account for more than 90% of the total population, but the racial composition varies within these areas. For instance, in Elyria, South Globeville, and Swansea, more than 80% of the population is of Hispanic origin, and less than 10% of the population is African-American. The Clayton and Cole neighborhoods, on the other hand, have a significantly higher number of African-American residents.

  Based on analyses of census data and other sources of information, Claritas has projected that the population of the VBI70 study area will grow roughly 5% between 1998 and 2003, with some growth expected to occur in all five neighborhoods.

- *Housing stock by neighborhood.* Information on the housing stock is an important consideration for this public health assessment, especially because surface soils can be greatly disturbed (or even replaced with clean fill) during construction of new homes. Table D-2 presents data on the housing stock in the VBI70 study area; these data are based on estimated information for 1998.

  As Table D-2 shows, there are more than 5,000 housing units in the VBI70 study area, with the Clayton and Cole neighborhoods having the highest numbers of homes. Throughout the study area, nearly 90% of the housing units were believed to be occupied in 1998. About three-fourths of the housing units in this area have only one unit (i.e., they are single family homes), and multi-unit dwellings are most prevalent in the Cole neighborhood.

According to the census data, more than 80% of the homes in the VBI70 study area were constructed before 1970, and most of these were built before 1950. Only 11% of the homes in the area were built in the last 15 years. New construction appears to be most prevalent in the Clayton and Cole neighborhoods. The South Globeville neighborhood, on the other hand, has the highest fraction of older homes. Though some variations in the age of homes are apparent in different parts of the VBI70 study area, the variations are not striking and cannot (by themselves) explain the trends observed in the soil contamination.

- *Length of residence by neighborhood.* The length of time people live in the VBI70 study area is very relevant to this public health assessment. People who have lived in the area for many years are much more likely to have come into contact with contaminated soils than people who have lived in the area for only a couple of years. According to Table D-3, the median duration of residence for "block groups" in the VBI70 study area ranges from 6.8 years to 23.3 years. (Note, a block group is a small subset of a neighborhood; the census uses block groups to report population data for parts of cities.) This means that residents in some parts of the VBI70 study area tend to move to new locations every 7 years or so, but residents in other parts of the VBI70 study area tend to not move from their homes for more than 23 years.

  For greater insight into duration of residence, the Claritas data was used to estimate how long people in the VBI70 study area live in their homes. These data are also shown in Table D-3. Averaged over the entire study area, 53% of the residents are believed to live in their current homes for 10 years or fewer, while only 16% of the residents are believed to have lived in their current homes for more than 30 years. Therefore, only about 16% of the residents have the potential for exposures greater than 30 years.

  Comparing these data across the five neighborhoods, ATSDR found that the percentage of long-term residents does not vary considerably from one neighborhood to the next. In fact, the percentages of long-term residents (30 years or more) in Clayton, Cole, Elyria, and Swansea are almost identical, with slightly higher percentages for South Globeville; a slightly different trend is observed if one considers "long-term residents" to be 11 years or more (see Table D-3). Overall, though some neighborhood-specific trends in duration of residency are apparent, no single neighborhood has a strikingly different distribution for this parameter than others. In other words, no single neighborhood stands out as having residents that have lived considerably longer in their homes when compared to the other four neighborhoods.

Table D-1
Demographic Data for the Five Neighborhoods in the VBI70 Study Area
(Data Presented Are Estimates of the 1998 Population)

Parameter	Data for the Population Living within the VBI70 NPL Site	Data for the Population Living within the VBI70 Study Area	Neighborhood				
			Clayton	Cole	Elyria	South Globeville	Swansea
Breakdown by Race:							
White	2,957 (67%)	7,635 (57%)	797 (20%)	2,484 (57%)	972 (89%)	742 (92%)	2,640 (89%)
African-American	1,250 (28%)	5,172 (39%)	3,040 (75%)	1,800 (41%)	69 (6%)	37 (5%)	227 (8%)
American Indian, Eskimo, or Aleut	84 (2%)	219 (2%)	48 (1%)	50 (1%)	43 (4%)	13 (2%)	65 (2%)
Asian or Pacific Islander	99 (2%)	273 (2%)	145 (4%)	58 (4%)	13 (1%)	16 (2%)	40 (1%)
Data on Residents of Hispanic Origin:							
Hispanic Origin	2,912 (66%)	7,712 (58%)	1,054 (26%)	2,686 (26%)	889 (81%)	661 (82%)	2,423 (82%)

Notes: The breakdown of the demographic data by white, African-American, American Indian, Eskimo, Aleut, Asian, and Pacific Islander is based on a question that is asked in the U.S. census. The sum of the percentages for these four entries should roughly equal 100% for each area.
Data on the number and percentage of residents of Hispanic origin is derived from an entirely separate question on the census. Therefore, this should be viewed as an altogether different breakdown of the VBI70 population.
All data in the table are estimates of 1998 population. These estimates were prepared for ATSDR by Claritas, Inc.

Table D-2
Data on the Housing Stock in the Five Neighborhoods in the VBI70 Study Area
(Data Presented Are Estimates for the Year 1998)

Parameter	Data for the Area within the VBI70 NPL Site	Data for the Area within the VBI70 Study Area	Neighborhood				
			Clayton	Cole	Elyria	South Globeville	Swansea
Total Housing Units and Occupancy Data:							
Total Housing Units	1,619	5,145	1,665	1,770	391	298	1,020
Total Occupied Housing Units	1,422	4,516	1,509	1,441	348	268	949
Estimated Occupancy Rate	88%	88%	91%	81%	89%	90%	93%
Distribution of Types of Housing Units:							
Single Unit Homes	1,272 (78%)	3,847 (75%)	1,273 (76%)	1,142 (65%)	285 (73%)	248 (83%)	899 (88%)
Homes with 2–9 Units	291 (18%)	978 (19%)	329 (20%)	448 (25%)	87 (22%)	31 (10%)	83 (8%)
Homes with 10 or More Units	35 (2%)	235 (5%)	50 (3%)	160 (9%)	6 (2%)	13 (4%)	5 (<1%)
Mobile Homes and Other	23 (1%)	84 (2%)	13 (1%)	20 (1%)	13 (3%)	6 (2%)	32 (3%)
Breakdown of Housing Stock by Year Homes Were Constructed:							
Homes Built in 1985 or Later	152 (9%)	590 (11%)	288 (17%)	232 (13%)	30 (8%)	12 (4%)	27 (3%)
Homes Built in 1980–1984	24 (1%)	97 (2%)	54 (3%)	27 (2%)	6 (2%)	9 (3%)	0 (0%)
Homes Built in 1970–1979	65 (4%)	288 (6%)	32 (2%)	113 (6%)	61 (16%)	13 (4%)	69 (7%)
Homes Built in 1950–1969	364 (22%)	983 (19%)	370 (22%)	173 (10%)	70 (18%)	31 (10%)	339 (33%)
Homes Built before 1950	1,015 (63%)	3,187 (62%)	921 (55%)	1,225 (69%)	224 (57%)	232 (78%)	584 (57%)

Note: All data in the table are estimates of the 1998 population. These estimates were prepared for ATSDR by Claritas, Inc.

Table D-3
Data on Duration of Residence for the Five Neighborhoods in the VBI70 Study Area
(Data Presented Are Estimates for the Year 1998)

Parameter	Data for the Population Living within the VBI70 NPL Site	Data for the Population Living within the VBI70 Study Area	Neighborhood				
			Clayton	Cole	Elyria	South Globeville	Swansea
Data on Median Duration of Residency (see notes at the bottom of the table):							
Shortest median length of residence for a block group within the area listed	6.8	6.8	11.4	6.8	8.5	7.7	8.5
Longest median length of residence for a block group within the area listed	12.2	23.3	18.2	23.3	15.0	14.1	15.0
Data on Duration of Residency: Percent of Householders Who Moved into Their Housing Units. . .							
. . . 0 to 5 years ago	42%	43%	39%	47%	57%	46%	37%
. . . 6 to 10 years ago	13%	10%	7%	10%	10%	3%	17%
. . . 11 or more years ago	45%	46%	53%	43%	33%	41%	46%
. . . 30 or more years ago	13%	16%	14%	16%	15%	20%	16%

Notes: The five neighborhoods in the VBI70 study area are comprised of many "block groups" or regions the U.S. Census uses to characterize the population. For each block group in these neighborhoods, the census data reports the median duration of residency for all of the residents in the block group. The data in the table above presents the lowest and highest median duration of residency for all block groups in a given area. Therefore, one can conclude that the median duration of residency for the entire neighborhood is between the lowest and highest data points provided.
In the second presentation of data, note that the last category ("30 or more years ago") is actually a subset of the category before it ("11 or more years ago"). Because of this, the percentages listed do not add up to 100.

Appendix E

Tables 1 through 5

Regional Geographic Initiative for Zip Code 80216

TABLE 1

MOBILE SOURCE EMISSION INVENTORY FOR THE GLOBEVILLE AREA

POLLUTANT	TONS PER DAY
CARBON MONOXIDE	10840.00
NITROGEN OXIDES	2044
HYDROCARBONS	1387
PM_{10}	657
$PM_{2.5}$	292
SULFUR DIOXIDE	73
VEHICLE MILES TRAVELED	781545665

TABLE 2

METALS EMISSIONS: 80216 by POLLUTANT AND COMPANY

SUBSTANCE	COMPANY	TONS PER YEAR	
ARSENIC COMPOUNDS	PUBLIC SERVICE COMPANY	0.25	
ANTIMONY COMPOUNDS	ASARCO INC GLOBE PLANT CHEMICAL& METAL IND INC	0.83 0.03	Total: .086
CADMIUM COMPOUNDS	ASARCO INC GLOBE PLANT	0.01	
CHROMIUM COMPOUNDS	PUBLIC SERVICE COMPANY OWENS CORNING/DENVER ROOFING PLANT	0.13 0.03	Total: 0.16
MANGANESE COMPOUNDS	OWENS CORNING/DENVER ROOFING PLANT	0.03	
NICKEL COMPOUNDS	PUBLIC SERVICE COMPANY	1.33	
LEAD (TSP)	ASARCO INC GLOBE PLANT	0.50	
LEAD COMPOUNDS	ASARCO INC GLOBE PLANT	0.01	
SELENIUM	ASARCO INC GLOBE PLANT	0.06	
TELLURIUM AND COMPOUNDS AS TE AND TE-PT	ASARCO INC GLOBE PLANT	0.13	

TABLE 3

TOTAL EMISSIONS: 80216 BY TONS PER YEAR OF POLLUTANT

TONS PER YEAR	POLLUTANT
18332.00	SULFUR DIOXIDE
16822.37	NITROGEN DIOXIDE
875.28	VOLATILE ORGANIC COMPOUNDS (VOC)
714.86	CARBON MONOXIDE
659.18	SUSPENDED PARTICULATE (TSP)
349.25	PM10 TOTAL 0-10UM
151.64	TOTAL HAZARDOUS AIR POLLUTANTS
144.43	ORGANIC COMPOUNDS
33.17	TOLUENE AKA METHYBENZENE
12.25	AMMONIA
6.53	CHLOROFORM
2.31	CHLORIDE
1.33	NICKEL COMPOUNDS
0.95	ACIDS
0.86	ANTIMONY COMPOUNDS
0.50	LEAD (TSP)
0.36	HYDROGEN SULFIDE
0.25	ARSENIC COMPOUNDS
0.18	ISOPHORONE
0.16	CHROMIUM COMPOUNDS
0.13	TELLURIUM AND COMPOUNDS, AS TE
0.06	SELENIUM COMPOUNDS
0.03	MANGANESE COMPOUNDS
0.01	TRIETHYLAMINE
0.01	CADMIUM COMPOUNDS
0.01	LEAD COMPOUNDS
******.**	HYDROFLUORIC ACID

TABLE 4

TOP 10 VOLATILE ORGANIC COMPOUND (VOC) AND HAZARDOUS POLLUTANT (HP) EMITTERS

SIC	VOC/HC	INDUSTRY	# of businesses
2051	VOC	Bakeries	3
2499	VOC/HC	Wood Products	1
2599	VOC/HC	Furniture Manufacturer	1
2711	VOC	Newspaper (printing)	2
2752	VOC/HC	Commercial Print and Lithograph	13 (HC=9)
2851	VOC/HC	Paints/Painting Facilities	1
2952	VOC	Asphalt	1
3086	VOC	Plastic Foam Products	1
3317	HC	Steel Pipe	1
3441	HC	Fabricated Structural Material	2
3443	HC	Fabricated Plate Work	1
3479	HC	Metal Coating	2
4911	VOC/HC	Electric Utility	1
5541	VOC	Gasoline Stations	9

TABLE 5

DIESEL FLEETS[43] BASED IN 80216
BY NUMBER OF TRUCKS

FLEET NAME	# OF TRUCKS
REGIONAL TRANSPORTATION DIST.	763
PENSKE TRUCK LEASING	604
CITY & COUNTY OF DENVER	411
DENVER PUBLIC SCHOOLS	315
RYDER TRUCK RENTAL-D.	281
HVH TRANSPORTATION, INC.	278
GLOBAL RENTAL	262
LEASE MIDWEST, INC.	225
ROLLINS LEASING CORP.-B	200
WASTE MANAGEMENT OF COLORADO	179
PEPSI-COLA BOTTLING CO.	144
U.S. WEST-DENVER	124
BRANNAN SAND & GRAVEL CO.	97
WESTERN DISTRIBUTING TRANS. C	75
ANHEUSER-BUSCH INC.	72
DON WARD & CO.	72
MAYFLOWER CONTRACT SERVICES	65
MILE-HI FROZEN FOODS CO.	58
N.P. TRANSPORTATION	57
READY MIXED CONCRETE CO.	56
SAFEWAY STORES, INC.	54
FULL SERVICE BEVERAGES	53
ZULANAS DISTRIBUTORS, INC.	46
ABF FREIGHT SYSTEMS, INC.	40
TRANS WESTERN EXPRESS, LTD.	40
BULLOCKS EXPRESS	38
RYDER TRUCK RENTAL-L.	38

[43] A fleet is considered to be nine or more trucks.

FLEET NAME	# OF TRUCKS
NEWS AND FILM SERVICE	33
NATIONAL BY-PRODUCTS, INC.	30
AMERICAN WAREHOUSE CO., INC.	26
FRANK C. KLEIN & CO., INC.	25
GIAMBROCCO FOOD SERVICE	24
WESTERN DELIVERY SERVICE	17
DPI DYKSTRA SALES, INC.	16
MOUNTAIN STATE TRUCK LEASING	15
BELLIO TRUCKING, INC.	14
IRON & METALS, INC.	13
ULTIMATE FROZEN FOODS, INC.	11
TOTAL	4871

Appendix F

Figure 11

Map of EPA's Regional Geographic Initiative for Zip Code 80216

Appendix G

CDPHE's Fact Sheet on Gardening in the VBI70 Study Area

Colorado Department of Health and Environment

April 1999

Home Gardening

For the residents of Globeville (south of I-70), Swansea, Elyria, Cole and Clayton neighborhoods

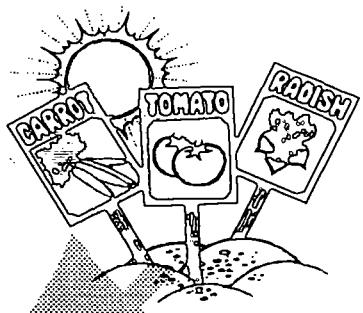
Several public health agencies are studying soil samples in your neighborhood to see if there are any metals present that might pose a health risk. More information will be available from these ongoing studies, and this information may need to be revised.

If you decide to garden this season, here is some general information about metals and gardening, and some steps that you can take to reduce the levels of metals that fruits and vegetables grown in your garden may take in if there are metals present in your garden soil.

Metals and gardening

- Garden soils tend to have less metal than the rest of the yard. This is because people have added commercial garden products or materials from outside the area like topsoil and compost to their garden soil.
- Fruits and vegetables from the garden usually have less metal than the soil they are grown in. This is because not all the metal is absorbed by the plants.
- The primary way plants take in metals is from the roots, along with the nutrients plants need for growth. A smaller amount of metals may get into the plant in small particles the plant "breathes" in through leaf openings. Metals may also be present in the dust or soil that collects on the outside of the plant.
- The ability of a plant to take up metals from soil and store them in their leaves and fruits varies from plant to plant.

What can I do to help protect my health?



Your garden soil

- You can add things such as compost, topsoil and phosphate from commercial and other outside sources to your garden soil. These products are available at your local garden store, will enrich your soil, and will help reduce the amount of metals that can be taken up by plants in your garden.

- After gardening be sure to wash up, especially your hands, clothes and shoes, to remove dust and soil and to avoid tracking soil into your home.

Your fruits and vegetables

- You can eat some fruits and vegetables grown from your garden, and some from the grocery store. This will reduce the possibility of being exposed to metals which may be in your garden soil.

- Wash and peel fruits and vegetables to reduce the amount of dust and dirt on the outside of fruits and vegetables.

You can call the following people at the Colorado Department of Public Health and Environment for more information

For information on garden studies/health effects:
Jane Mitchell
(303) 692-2644 or 1(800)886-7689
jane.mitchell@state.co.us

Nancy Strauss *(habla español)*
(303) 692-2785 or 1(800)886-7689
nancy.strauss@state.co.us

For information on metals in your soil:
Barbara O'Grady
(303) 692-3395 or 1(888)569-1831
barbara.ogrady@state.co.us

Marion Galant
(303) 692-3304 or 1(888)569-1831
marion.galant@state.co.us

For more information about metals in your soil or health effects, you may call the Agency for Toxic Substances and Disease Registry, Regional Representative Susan Muza at (303) 312-7011. For more information about gardening in general, you can call the Colorado State University Cooperative Extension Master Gardener at (303) 640-5278.

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Appendix H

ATSDR's Fact Sheet Evaluating Gardening in the VB170 Study Area

Eating Vegetables from your Garden in Swansea, Elyria, Cole, Clayton, & South Globeville

Soil Sampling in your Neighborhood . . .

As you might know, soil from yards in the Vasquez Boulevard and Interstate 70 Superfund Site study area (VBI-70 area) is currently being tested to see if it contains elevated levels of metals such as arsenic and lead. The study area includes the communities of Swansea, Elyria, Cole, Clayton, and south Globeville (south of Interstate 70 and west of Interstate 25). As the sample results become available, several public health agencies are looking at them to see if the metals that are found could cause health problems.

Eating Vegetables from your Garden . . .

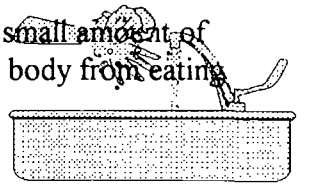
The Agency for Toxic Substances and Disease Registry (ATSDR) along with the Colorado Department of Public Health and Environment (CDPHE) just finished an evaluation that looked at fruits and vegetables that are grown in yards where metals are found in the soil. Since arsenic is the metal that has been found most often at elevated levels in the yards that have been sampled so far, the study answered these questions about arsenic:

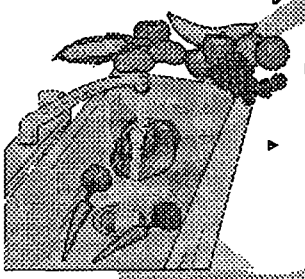
✓ **If elevated levels of arsenic are found in the soil of gardens in the VBI-70 area, is it safe to eat home-grown fruits and vegetables?**

Yes, it is safe to eat fruits and vegetables that are grown in your garden in the VBI-70 area. It is not likely that eating home-grown fruits and vegetables will be harmful.

✓ **If there are elevated levels of arsenic in the soil, will arsenic also be found in the fruits and vegetables?**

Fruits and vegetables that are grown in soils with any level of arsenic will take up a small amount of arsenic through their roots. But the amount of arsenic that might be taken into your body from eating these fruits and vegetables is far below the levels that are known to cause illness.





✓ **Are there healthy ways to garden?**

Yes, the following tips are healthy practices for all gardeners:

- Wash your hands after working in the garden and before handling fruits and vegetables.
- Wash fruits and vegetables, especially low-growing vegetables like collard greens, spinach, and lettuce that are grown in your garden.

For More Information . . .

For more information about gardening and other health studies in your area, you may contact:

David Mellard	*Lourdes Rosales-Guevara*	*Jane Mitchell*
ATSDR	ATSDR (Spanish speaking)	CDPHE
1-888-42-ATSDR	1-888-42-ATSDR	(303) 692-2644

Appendix I

Figures 12 - 17

Lead and zinc distribution maps for the study area

Appendix J

Figures 18 and 23

Arsenic distribution maps for the study area

Appendix K

Figures 24 through 26

Lead and arsenic distribution maps at individual properties

Appendix L

Information Sheet: Ways to Protect Your Health

Appendix M

ATSDR's letter informing EPA of questions raised by community representatives

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Agency for Toxic Substances
and Disease Registry
Atlanta GA 30333

March 24, 1999

Ms. Bonnie Lavelle, RPM
US EPA Region VIII
8EPR-RP
999 18th Street, Suite 500
Denver, CO 80202

Re: Community Concerns

Dear Ms. Lavelle:

As you know, the Agency for Toxic Substances and Disease Registry (ATSDR) has started activities associated with its public health assessment of the Vasquez Boulevard site (VBI70). One of the major components of the public health assessment is to identify and address community health concerns. To date, the VBI70 health team has met and conducted numerous conference calls with representatives from various neighborhood organizations around the site. The VBI70 health team consists of representatives from ATSDR, Colorado Department of Public Health and Environment, Denver Department of Environmental Health, and community representatives. Community representatives on the VBI70 health team have told us many of their concerns.

As we discussed with you earlier, some concerns that the community representatives have expressed are outside of ATSDR's responsibilities in the Superfund process. We have informed the community representatives that when concerns come up that are more appropriately answered by other agencies, we will convey those concerns to the appropriate agency or organization.

Listed below are the concerns that have been raised that would best be answered by the EPA. Our responses to the community representatives on certain concerns are in italics.

1. Community representatives expressed a need to understand the sampling methods the EPA used at the VBI70 site. Specifically, they want to understand the difference between a composite versus an average, and how the difference between the two is used in risk assessment. Community representatives also want to know why the EPA did not sample for cadmium and zinc.

   ATSDR realizes that while some sampling was done for cadmium and zinc (for example, some of the confirmatory samples measured for cadmium and zinc), the community representatives did not understand the EPA's previous explanations.

2. Community representatives want to know the reasons certain houses were deleted from the list of houses for an emergency cleanup?

   We discussed the EPA's explanation and handout given during the January 28th working group meeting with the community respresentatives. During our discussion with the community representatives, we realized that they had concerns about the selection of properties for removal activities and related topics. For instance,

community representatives disagreed with the way houses were selected for sampling. Other issues that were raised included questions about the sampling approach, door-to-door canvassing, testing before action levels are set, and Phase III samples. We suggested to the community representatives that they discuss the issues with you.

I think the community representatives understand the EPA's reasons for selecting homes for removal activities but may still disagree with those reasons. In addition, they have other concerns related to the selection of homes for removal, as well as sampling and timing issues. EPA staff members may want to talk to the community representatives again about the issues mentioned to have a better understanding of their concerns and questions.

3. Community representatives want to know beforehand the meanings of environmental and health terms that might be used during work group discussions. During our discussions with them, they did not specify any terms in particular, although I remember them mentioning MRLs and RfDs as examples during work group meetings.

   I have agreed to put together a short dictionary of scientific terms that ATSDR might use. We are also passing the concern on to you since the EPA has its own scientific terms and jargon.

4. Community representatives expressed a need to better understand the EPA's risk assessment process. They also wish to have the explanation in writing.

As we continue to receive concerns related to the EPA, we will forward them to you. Thank you for your attention to these issues. If I can provide you with additional information, please contact me at (404) 639-0639.

Sincerely,

for

David Mellard, Ph.D.
Toxicologist
Division of Health Assessment and Consultation

cc:
Ms. Joan Hooker
Mr. Anthony Thomas
Ms. Sandy Douglas
Ms. Melissa Muñoz
Ms. Rosemary Riley
Ms. Lorraine Granado
Ms. Barbara O'Grady
Ms. Celia VanDerLoop
Ms. Susan Muza